Parasite Images

Listed Alphabetically

ALPHABETICAL LISTING (A-Z)

Acetodextra sp.
Allochanthochasmus sp.
African sleeping sickness (African trypanosomiasis)
Amblyomma americanum (lone star tick)
American trypanosomiasis (Chagas' Disease)
Allocreadium sp.
Alloglossidium sp.
American cockroach (*Periplaneta americanus*)
Amoebiasis (*Entamoeba histolytica*)
"Anchor worm" (*Lernea* sp.)
Ancylostoma spp. (hookworms)
Angiostrongylus cantonensis
Anisakis sp.
Anopheles sp.
Apocreadium sp.
Apophallus sp.
Argulus sp.
Arthrocephalus (=Placoconus) sp.
Ascaris sp. (human and pig roundworms)
Aspidogaster sp.
Auridistomum sp.
Babesia bigemina (babesiosis)

Balantidium coli
Baylisascaris procyonis
Bedbugs (*Cimex* spp.)
Bilharziasis (schistosomiasis)
Black-legged tick (*Ixodes scarpularis*)
"Black spot" in fish (*Uvulifer amboplitis*)
Body louse (*Pediculus humanus*)
Boophilus microplus (southern cattle tick)
Bot(s) (bot fly)
Bothriocepalus sp.
Brugia malayi (brugian filariasis)
Camallanus sp.
Capillaria hepatica
Capillaria philippinensis
Cattle tick (*Boophilus microplus*)
Cephalogonimus sp.
Cercarial dermatitis
Chagas' Disease (American trypanosomiasis)
Chigger (*Tunga penetrans*)
Chigoe (*Tunga penetrans*)
Chilomastix mesnili (a commensal)
Chique (*Tunga penetrans*)
Choanotaenia sp.
Cimex spp. (bedbugs)
Clonorchis sinensis (Chinese/Oriental liver fluke)
Cockroach, American (*Periplaneta americanus*)
Coccidiosis (*Eimeria* and *Isospora*)
Conspicuum sp.
Cooperia spp.
Corallobothrium sp.
Cosmocerella sp.
Cotylaspis sp.
Cotylurus *sp.*
Crab louse (*Phthirus pubis*)

***Crepidostomum* sp.**
Cryptobia salmositica
***Cryptosporidium parvum* (cryptosporidiosis)**
***Ctenocephalides* sp. (fleas)**
Cutaneous larval migrans (CLM)
Cuterebids (bot flies)
Cyclospora cayetanesis
Cysticercosis
Deer flies (*Tabanus* sp.)
Deer tick (*Ixodes scarpularis*)
Dehli boil
Demodectic mange
***Demodex* sp. (follicle mites)**
***Dermacentor* sp. (dog tick)**
***Dicrocoelium dendriticum* (lancet fluke)**
***Dictyangium* sp.**
Dientamoeba fragilis
Dioctophyme renale
Diphyllobothrium latum
Diplogonoporus grandis
***Diplostomulum* sp.**
***Dipylidium caninum* (cucumber tapeworm)**
***Dirofilaria immitis* (canine heartworm)**
Dog tick (*Dermacentor* sp.)
Dracunculiasis
Dracunculus medinensis
Dum-Dum fever
***Echinococcus granulosus* *Echinococcus multilocularis* (hydatid disease)**
***Echinorhynchus* sp.**
***Echinostoma* spp.**
***Eimeria* sp. (coccidiosis)**
Elephantiasis (filariasis)
***Endolimax nana* (a commensal)**

Entamoeba coli (a commensal)
Entamoeba histolytica (amoebiasis, dysentery)
Enterobius vermicularis (pinworms)
Eosinophilic meningoencephalitis *Angiostrongylus cantonensis*
Epistylis sp.
Ergasilus sp.
Espundia
Eurytrema pancreaticum
Eustrongylides sp.
Face mange (*Notoedres cati*)
Fasciola hepatica (sheep liver fluke)
Fascioloides magna
Fasciolopsis buski
Fiery serpent (*Dracunculus medinensis*)
Filariasis (elephantiasis)
Fleas (*Ctenocephalides* sp.)
Follicle mites (*Demodex* spp.)
Giardia lamblia (giardiasis)
Glaridacris catostomus
Glossina sp. (tsetse or tsetse fly)
Gordius sp. (horsehair worms)
Gregarina sp.
Guinea worm (*Dracunculus medinensis*)
Gyrocotyle sp.
Gyrodactylus sp.
Haematoloechus medioplexus (frog lung fluke)
Haemonchus spp.
Haplobothrium sp.
Heartworm (*Dirofilaria immitis*)
Hemogregarina sp.
Heterophyes heterophyes
Hookworms (*Ancylostoma* and *Necator*)
Horse flies (*Tabanus* sp.)

Horsehair worms (Nematomorpha)
Hydatid disease (hydatidosis)
Hymenolepis spp.
Hymenolepis diminuta
Hymenolepis nana (Vampirolepis nana)
Ichthyophthirius multifiliis("ick" in fish)
"Ick" in fish *(Ichthyophthirius multifiliis)*
Iodamoeba butschlii (a commensal)
Isospora sp. (coccidosis)
Isospora belli
Ixodes scarpularis (Black-legged or deer tick)
Jericho boil
Jigger (*Tunga penetrans*)
Kala-azar
Leishmania spp. (leishmaniasis)
Leptorhynchoides sp.
Lernea sp. ("anchor worm")
Leucochloridium sp.
Lice (body and pubic)
Ligula intestinalis
Lissorchis sp.
Loa loa
Lone star tick (*Amblyomma americanum*)
Loxogenes sp.
Lutztrema sp.
Macracanthorhynchus hirudinaceus
Malaria (*Plasmodium* spp.)
Mange
Megalodiscus temperatus
Meningoencephalitis *Angiostrongylus cantonensis*
Mesocestoides sp.
Metagonimus yokogawai
Metorchis conjunctus

Microcotyle sp.
Microphallus sp.
Moniezia expansa
Moniliformis sp.
Multiceps serialis (Taenia serialis)
Myxobolus ("whirling disease")
Necator americanus (hookworms)
Nematodirus spp.
Nematomorpha (horsehair worms)
Notoedres cati
Notocotylus notocotylus
Obeliscoides cuniculi
Octomacrum sp.
Onchocerca volvulus (onchocerciasis, riverblindness)
Ophiotaenia sp.
Ornithodorus turicata
Ostertagia spp.
Panstrongylus megistus
Parabascus sp.
Paragonimus westermani (human lung fluke)
Pediculus humanus (body louse)
Periplaneta americanus (American cockroach)
Philometra sp.
Pinworms (*Enterobius vermicularis*)
Placobdella sp.
Placoconus sp.
Plagiorhynchus sp.
Plasmodium spp. (malaria)
Platynostomum sp.
Pleorchis sp.
Polymorphus minutus
Pomphorhynchus sp.
Polystoma sp.
Polystomoides sp.

Toxocara canis (canine roundworm)
Toxoplasma gondii (toxoplasmosis)
Triaenophorus crassus
Triatoma infestans
Tribolium confusum (confused flour beetle)
Trichinella spiralis (trichinosis)
Trichodina sp.
Trichomonas vaginalis (trichomoniasis)
Trichostrongylus spp.
Trichuris spp. (whipworms)
Triganodistomum sp.
Trypanorhynchid cestodes
Trypanosoma cruzi (American trypanosomiasis, Chagas' Disease)
Trypanosoma spp. (African trypanosomiasis, "sleeping sickness")
Tsetse or tsetse fly (*Glossina* sp.)
Tunga penetrans
Urogonimus sp.
Uta
Uvulifer ambloplitis ("black spot" in fish)
Vampirolepis nana (Hymenolepis nana)
Visceral larval migrans (VLM)
Warble(s)
Watsonius sp.
Whipworms (*Trichuris* spp.)
"Whirling disease" in fish (*Myxobolus* sp.)
Wuchereria bancrofti (filariasis)
Zonorchis sp.
Zygocotyle lunata
A MOST UNUSUAL SPECIMEN

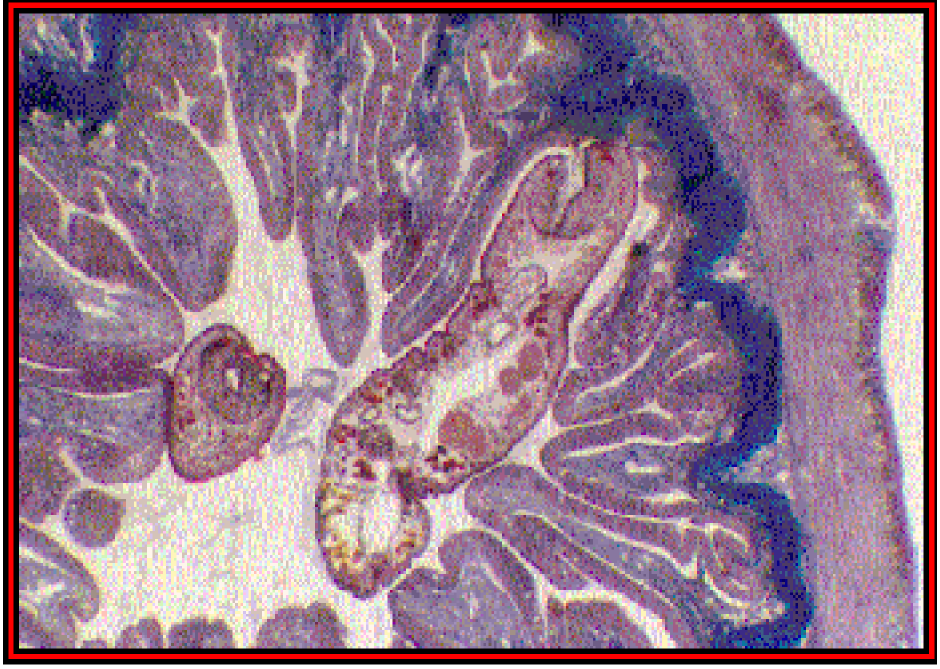
Graphic Images of Parasites

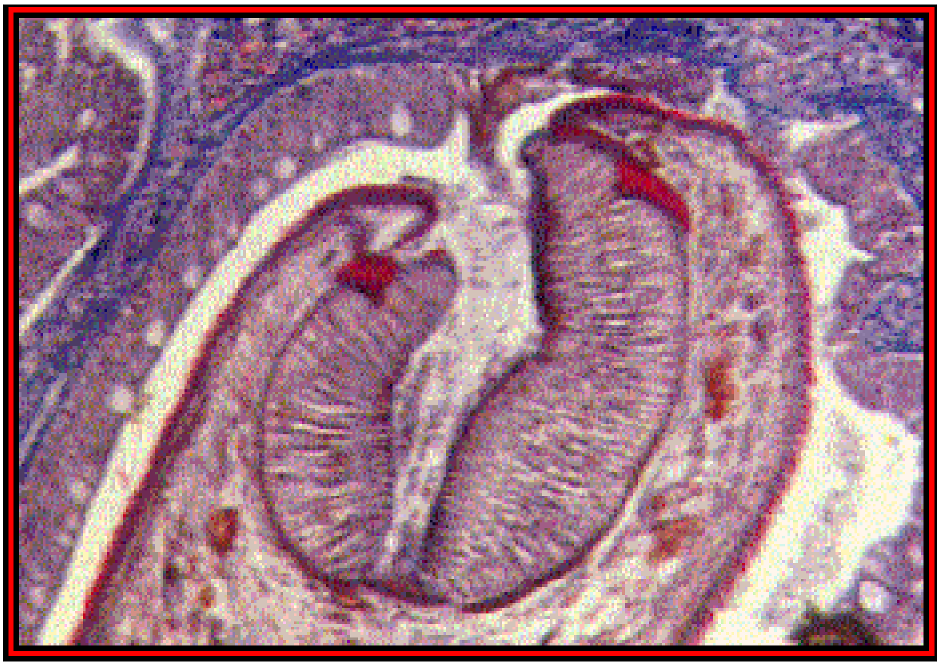
Acetodextra sp.

Allochanthochasmus sp.

A whole mount of *Allochanthochasmus* sp. from a white bass.

A live specimen of *Allochanthochasmus* sp. from a white bass. Note the ring of small spines around the oral opening, a characteristic of some genera in the family Cryptogonimidae.





Histological sections showing *Allochanthochasmus* sp. in the intestine of a white bass.

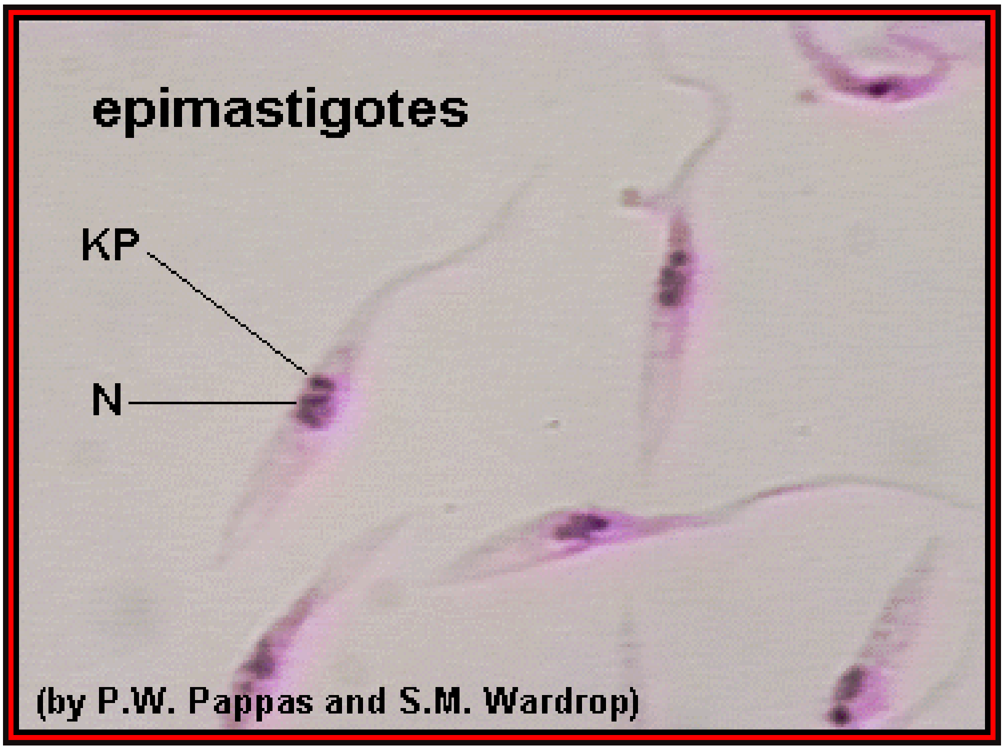
Trypanosoma spp.

(African trypanosomiasis)

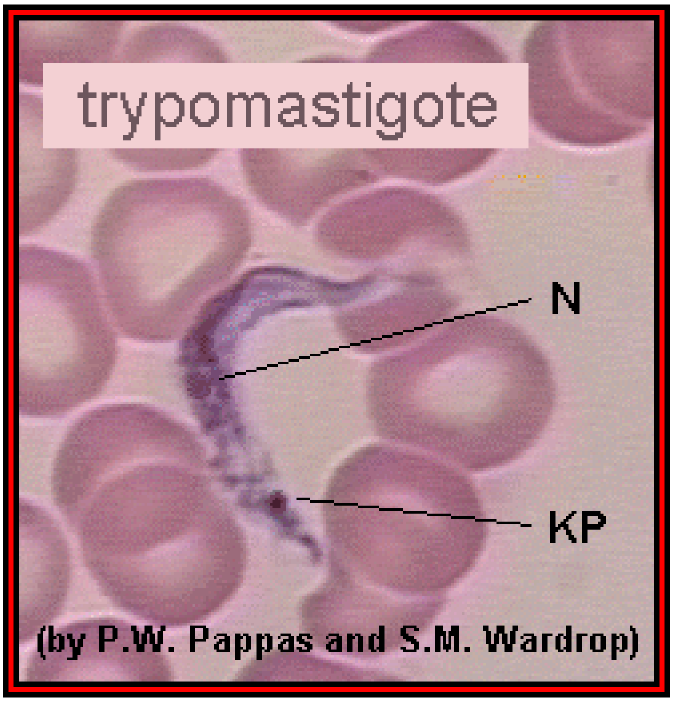
The genus *Trypanosoma* is large and diverse. It includes several species that infect wild and domesticated animals in Africa, particularly hoofed animals, and humans. Most of the African trypanosomes are transmitted by vectors (the one exception is a sexually transmitted disease of horses), and the most common vector is the tsetse fly (*Glossina* sp.). The species that cause human African trypanosomiasis ("sleeping sickness") also infect wild animals and can be transmitted from these animals to humans (zoonotic infections). As their names imply, most African trypanosomes are restricted to Africa, although a few species have been imported into South America (view the geographic distribution).

The life cycles of most African trypanosomes are similar. In the vertebrate host (.e.g., human) the parasite grows and reproduces as a trypomastigote form in the blood of the infected host. When a vector ingests trypomastigotes during a blood meal, the trypomastigotes transform into epimastigotes and grow and reproduce in the vector's gut or salivary glands. The epimastigotes transform into trypomastigotes, and these infect a new host the next time a vector takes a blood meal (view a diagram of the life cycle). The various life cycle stages of the different species of *Trypanosoma* are virtually indistinguishable morphologically.

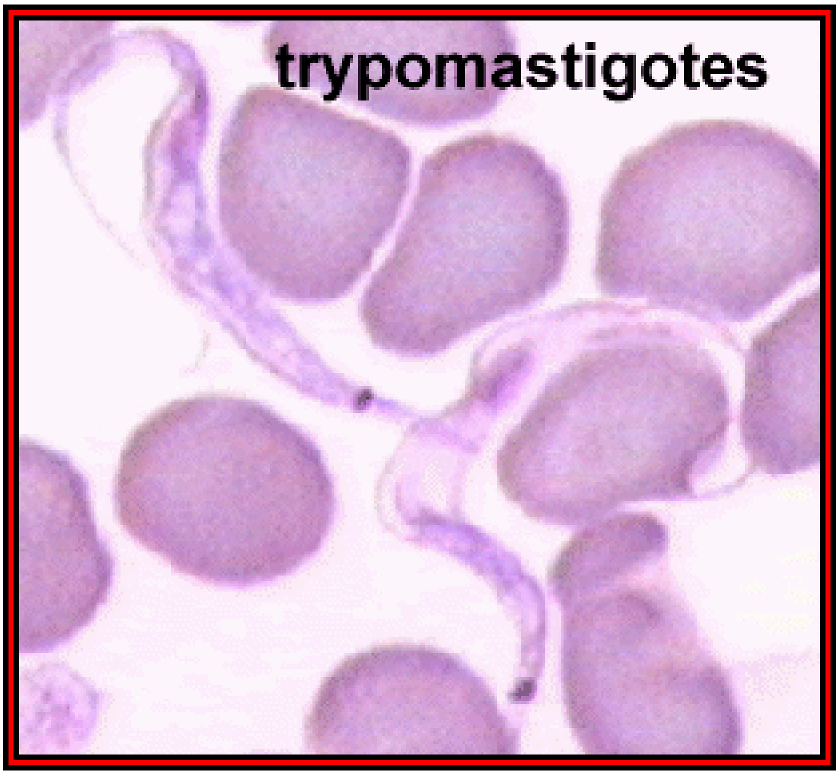
A few species of *Trypanosoma* are also found in the New World. From the standpoint of human health, the most important is *Trypanosoma cruzi* which causes American trypanosomiasis or Chagas' disease. Chagas' disease is found throughout much of central and northern South America, Central America, and Mexico. *T. cruzi* is found in a number of animals other than humans, including dogs, cats and rodents, but it is not known how often infections in these animals are transmitted to humans.



Epimastigotes of *Trypanosoma* grown in culture; in this form the kinetoplast (KP) is anterior to the nucleus (N). In most species of *Trypanosoma*, this is the life cycle stage that reproduces in the gut of the vector. The epimastigotes measure approximately 30 µm in length.



Trypomastigotes of *Trypanosoma* in a blood smear; in this form the kinetoplast is posterior to the nucleus. This life cycle stage is found in all species of *Trypanosoma*, and in most species it is the only stage that reproduces in the vertebrate (human) host.

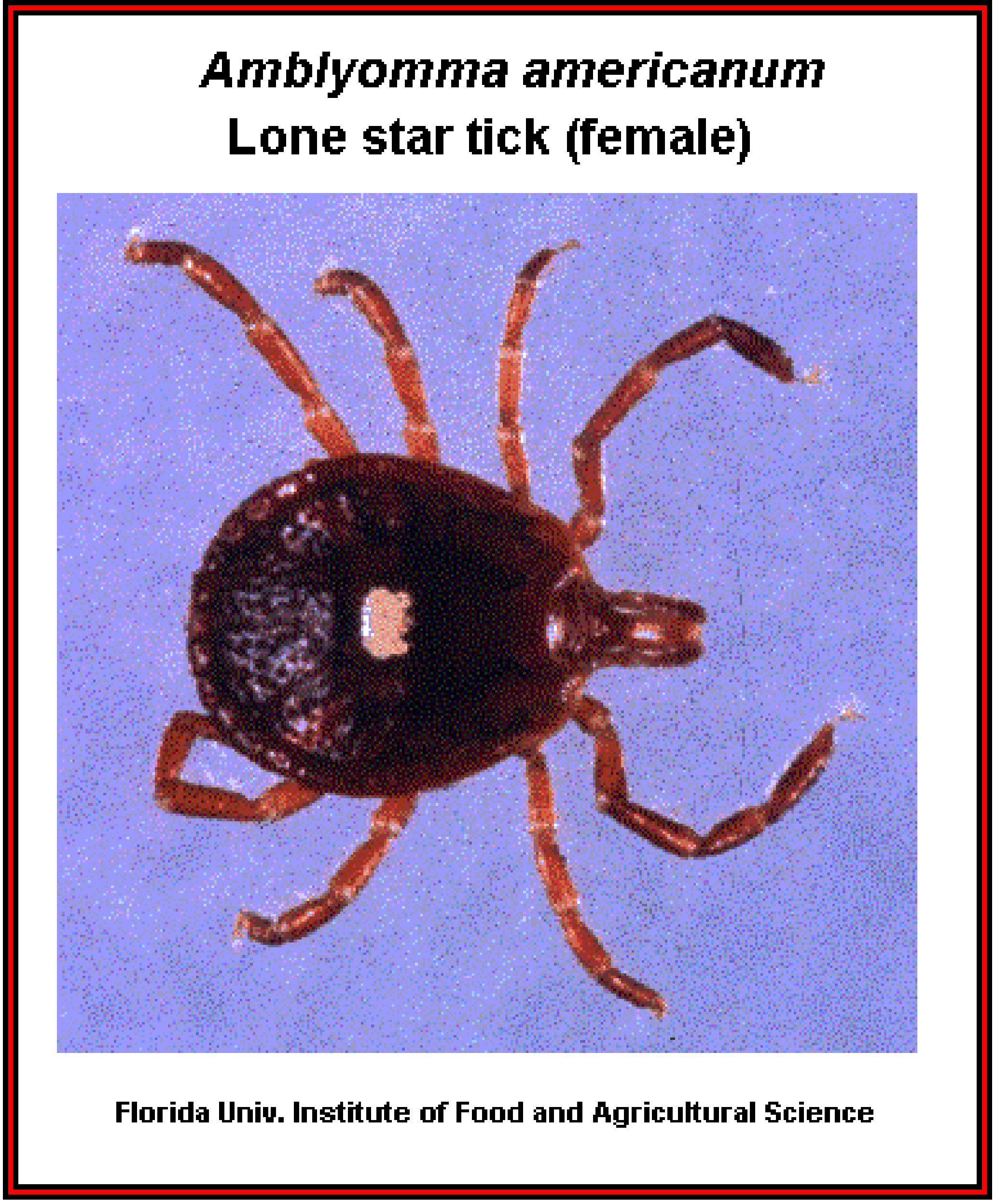


Another example of trypomastigotes. The posterior kinetoplast shows up particularly well. (Original images from "Atlas of Medical Parasitology.")

Amblyomma americanum
(lone star tick)

The lone star tick, *Amblyomma americanum*, is restricted to the southern part of the United States. It can serve as the vector for Rocky Mountain spotted fever and tularemia.

A male *Amblyomma americanum.*



A female *Amblyomma americanum*.

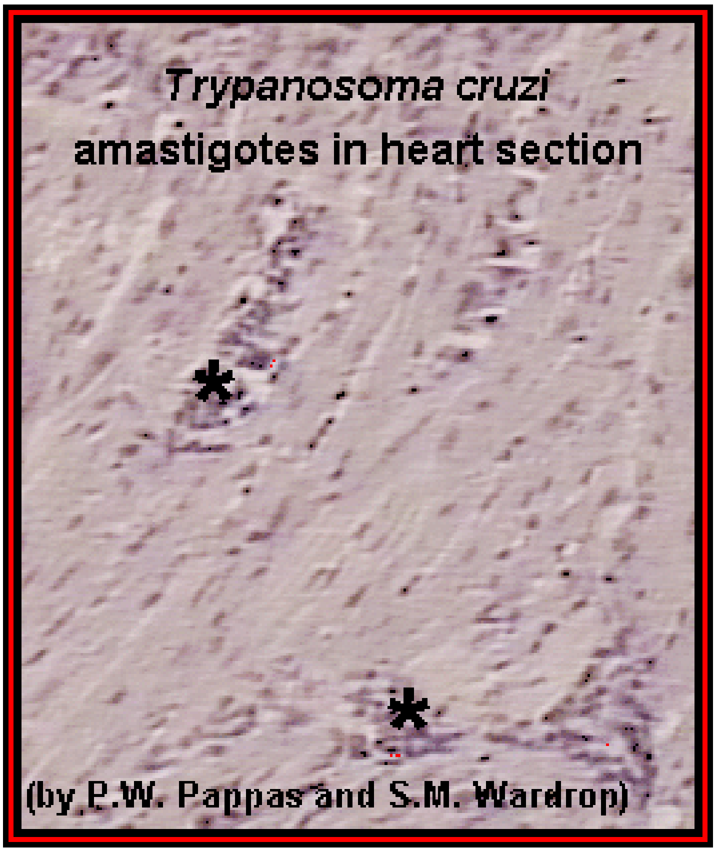
An ovipositing lone star tick, *Amblyomma americanum*. (Scanned and modified from a transparency provided by Jim Occi.)

Trypanosoma cruzi

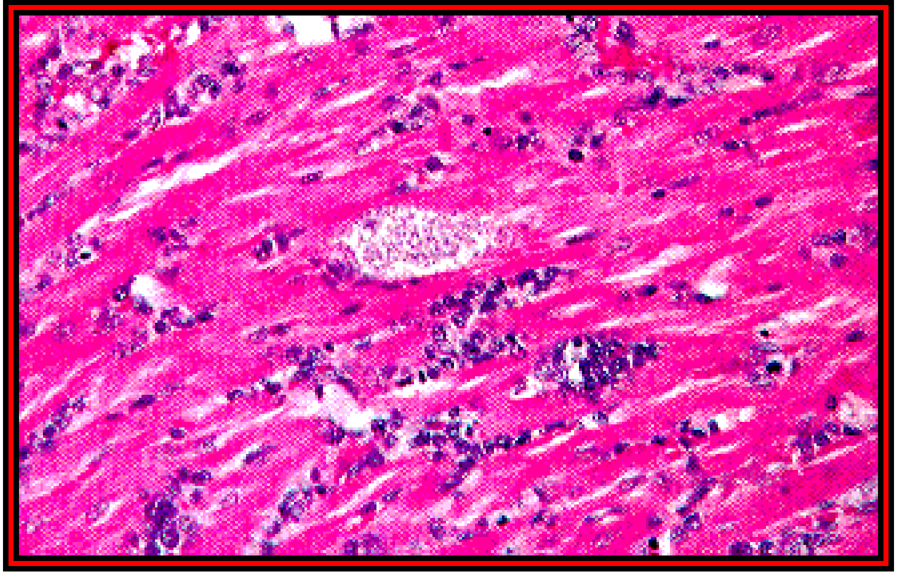
(American trypanosomiasis, Chagas' disease)

A few species of *Trypanosoma* are found in the New World. From the standpoint of human health, the most important is *Trypanosoma cruzi*, causing American trypanosomiasis or Chagas' disease. Chagas' disease is named after Carlos Chagas, a Brazilian who in 1910 discovered this parasite in the vector. (Thus, the correct name is Chagas' disease, not Chaga's disease.) The parasite is found throughout much of central and northern South America, Central America, and Mexico (view geographic distribution). *T. cruzi* is found in a number of animals other than humans, including dogs, cats, and rodents, and infections of such reservoirs in the United States have been reported. However, it remains unclear whether the *T. cruzi* found in these reservoirs can actually be transmitted to humans.

In humans, *T. cruzi* is found as both an intracellular form, the amastigote, and as a trypomastigote form in the blood. The vector for Chagas' disease, a "true bug" (Hemiptera) such a *Triatoma*, *Rhodnius*, or *Panstrongylus*, ingests amastigotes or trypomastigotes when it feeds. In the vector the parasite reproduces asexually and metacyclic trypomastigotes are found in the vector's hindgut. The vector defecates on the host's skin at the same time that it feeds, and the metacyclic trypomastigotes enter the host's body, most often by being "rubbed in" to the vector's bite or the mucous membranes of the eye, nose, or mouth (view a diagram of the life cycle). In the human host, Chagas' disease affects primarily the nervous system and heart. Chronic infections result in various neurological disorders, including dementia, megacolon, and megaesophagus, and damage to the heart muscle. Left untreated, Chagas' disease is often fatal.



Amastigotes (*) of *Trypanosoma cruzi* in heart muscle.

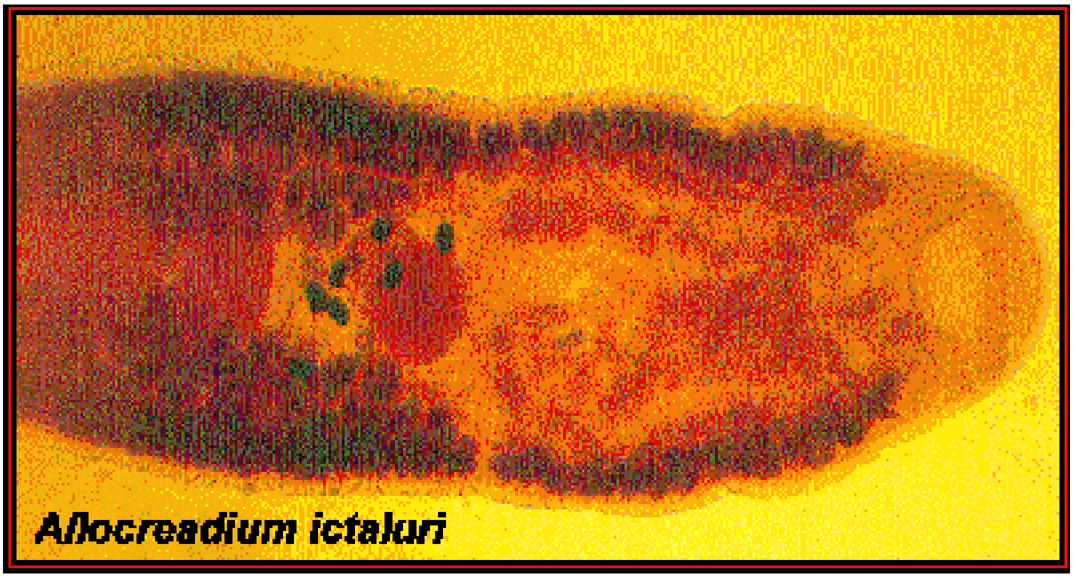


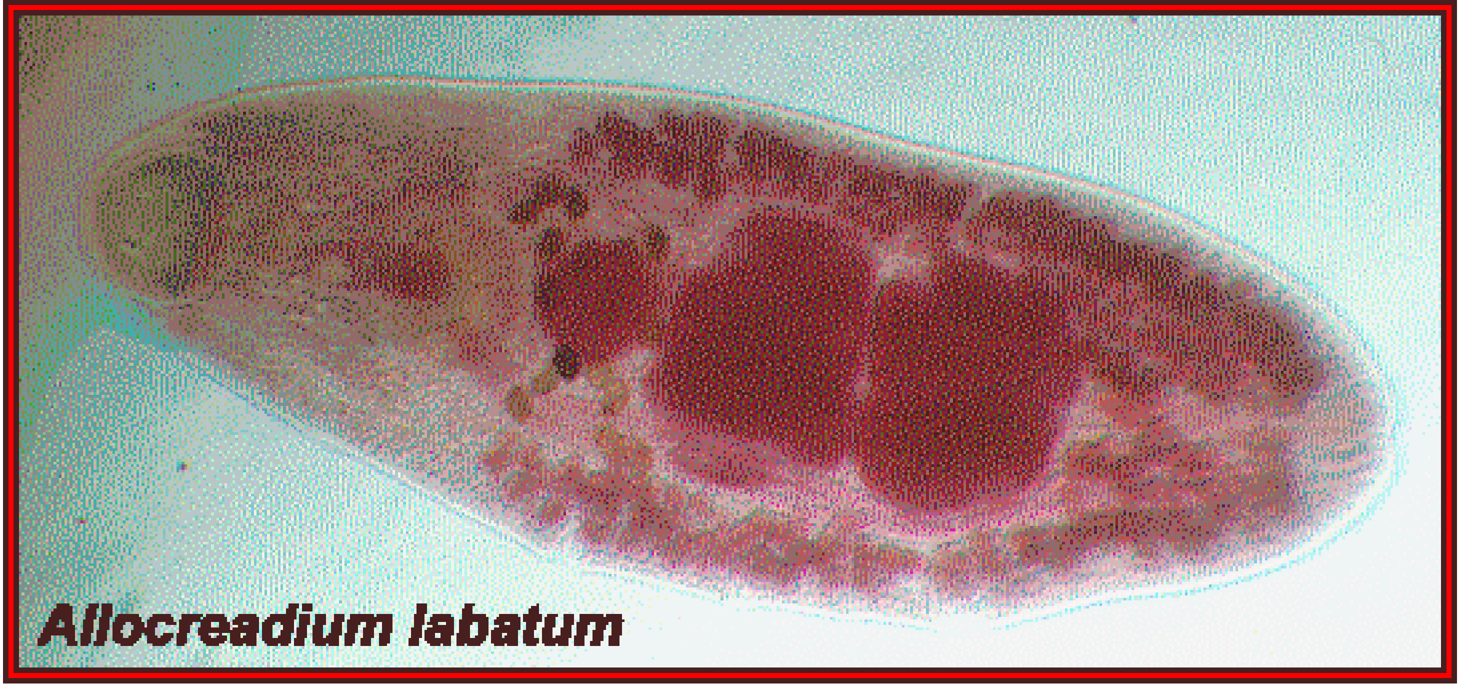
Amastigotes (pseudocyst) of *T. cruzi* in the heart of a dog. (From: Gardiner *et al*., 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)

Trypomastigote of *T. cruzi*. These forms often have a characteristic "C" shape.

Allocreadium sp.

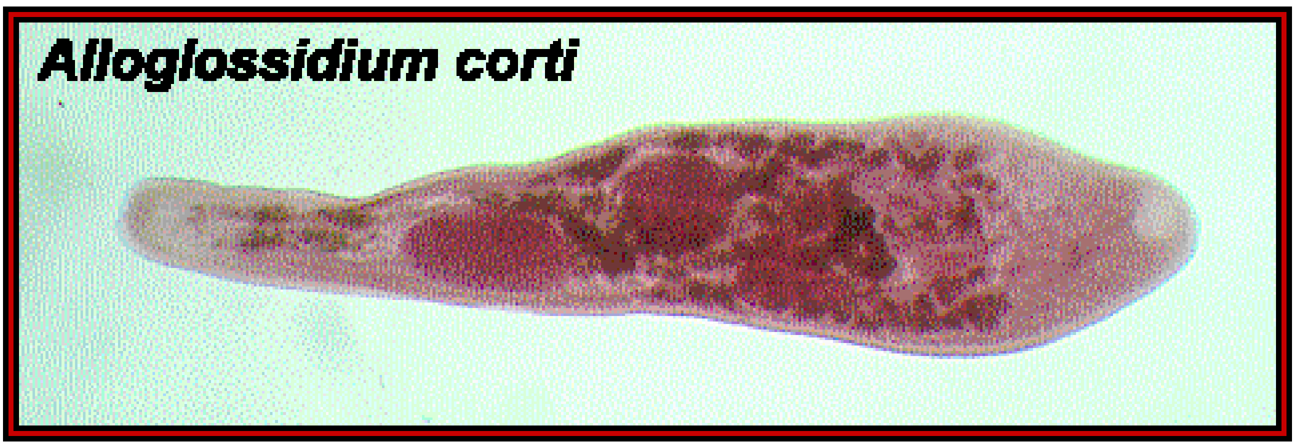
Very little is known of the life cycles of members of this genus. In *Allocredium ictaluri*, a parasite of the catfish, rediae develop in the snail, *Pleurocerca acuta*, and cercariae encyst in unionid clams. However, in other species of *Allocredium*, such as *A. angusticolle* in Europe, the snail is *Neritina fluviatilis*, and the cercariae encyst in gammarids.




Allocreadium labatum

Alloglossidium corti

This is an intestinal trematode that infects several species of fish. The first intermediate host is a snail (e.g., *Helisoma trivolis* or *H. campanulatum*), and cercariae encyst in mayfly or dragonfly nymphs, or in crayfish.



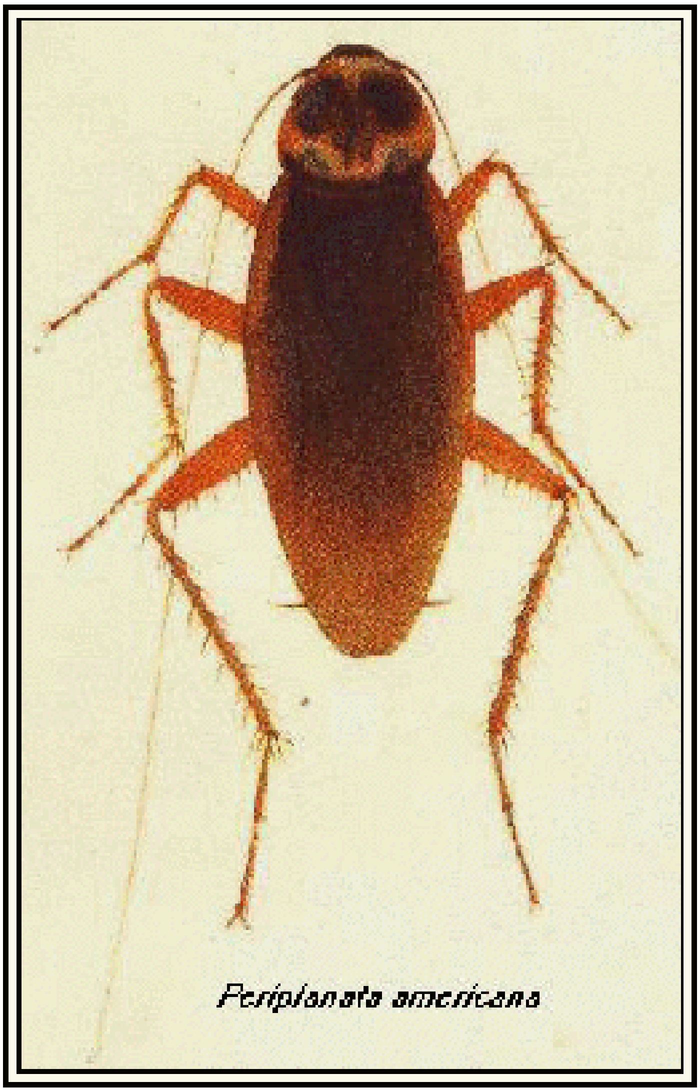

Alloglossidium corti

Graphic Images of Parasites

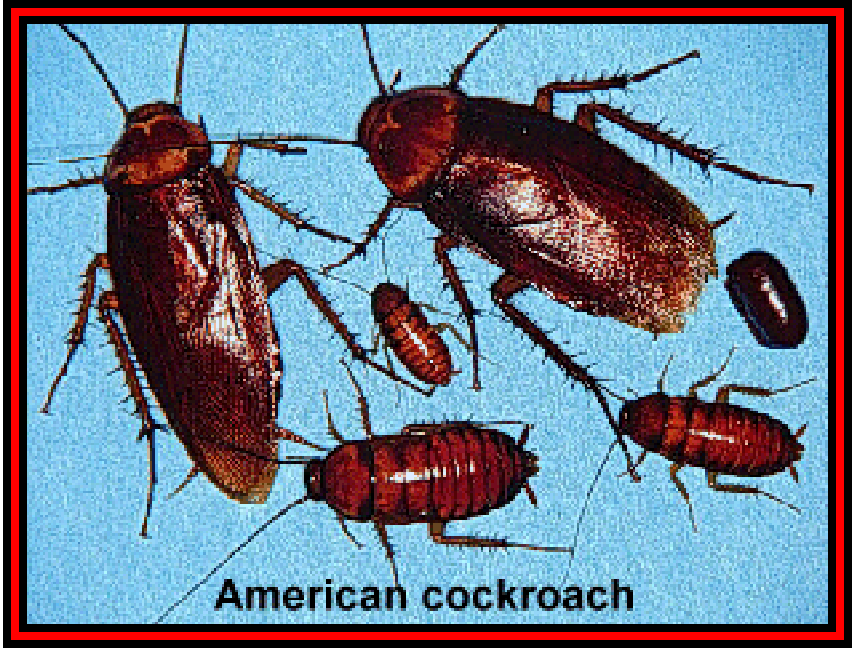
Periplaneta americana
(American cockroach)

Cockroaches can disseminate a number of human parasitic diseases. For example, their external surfaces could be contaminated with protozoan cysts or helminth eggs, and these infectious stages could be deposited in areas where one would not expect to find the cysts or eggs. "Filth flies" can disseminate infections by the same mechanism. In this sense, cockroaches serve as mechanical vectors. Cockroaches do not, however, serve as biological vectors for any parasitic diseases of humans.

The American cockroach, *Periplaneta americana*, is the intermediate host for the acanthocephalan, *Moniliformis moniliformis*. This is a parasite of the small intestines of rats, and it has been used as an experimental model to study the biology of acanthocephala.



Periplaneta americana, the American cockroach.

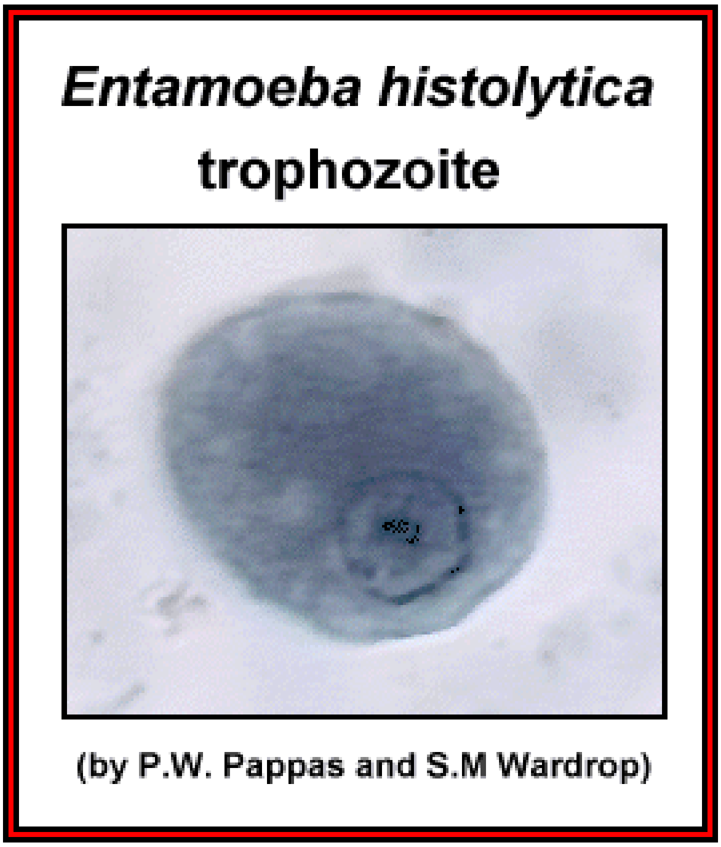


The various life cycle stages of the American cockroach. Copyright Jim Kalisch, Department of Entomology, University of Nebraska - Lincoln.

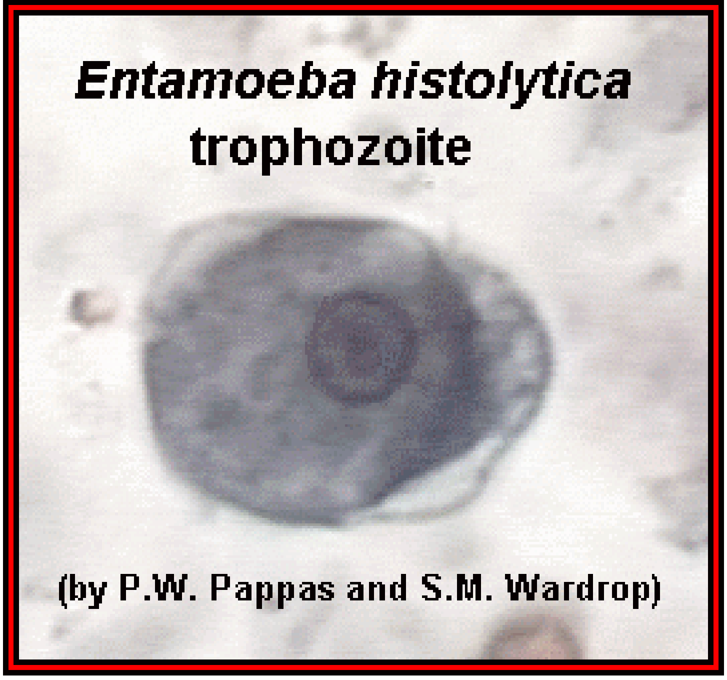
Entamoeba histolytica
(amoebiasis/amoebic dysentery)

The life cycle of *Entamoeba histolytica* involves trophozoites (the feeding stage of the parasite) that live in the host's large intestine and cysts that are passed in the host's feces. Humans are infected by ingesting cysts, most often via food or water contaminated with human fecal material (view diagram of the life cycle). The trophozoites can destroy the tissues that line the host's large intestine, so of the amoebae infecting the human gastrointestinal tract, *E. histolytica* is potentially the most pathogenic. In most infected humans the symptoms of "amoebiasis" (or "amebiasis") are intermittent and mild (various gastrointestinal upsets, including colitis and diarrhea). In more severe cases the gastrointestinal tract hemorrhages, resulting in dysentery. In some cases the trophozoites will enter the circulatory system and infect other organs, most often the liver (hepatic amoebiasis), or they may penetrate the gastrointestinal tract resulting in acute peritonitis; such cases are often fatal. As with most of the amoebae, infections of *E. histolytica* are often diagnosed by demonstrating cysts or trophozoites in a stool sample.

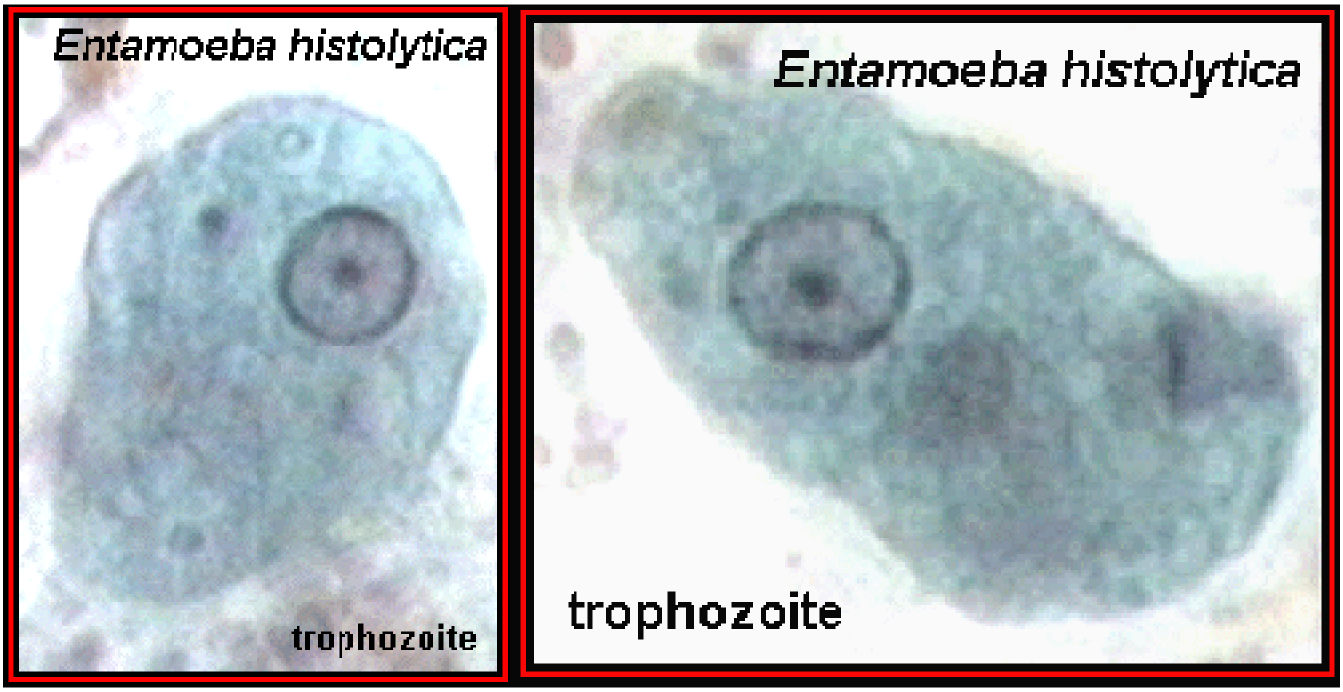
The internal morphology can be seen in a phase contrast photomicrograph (view the image).



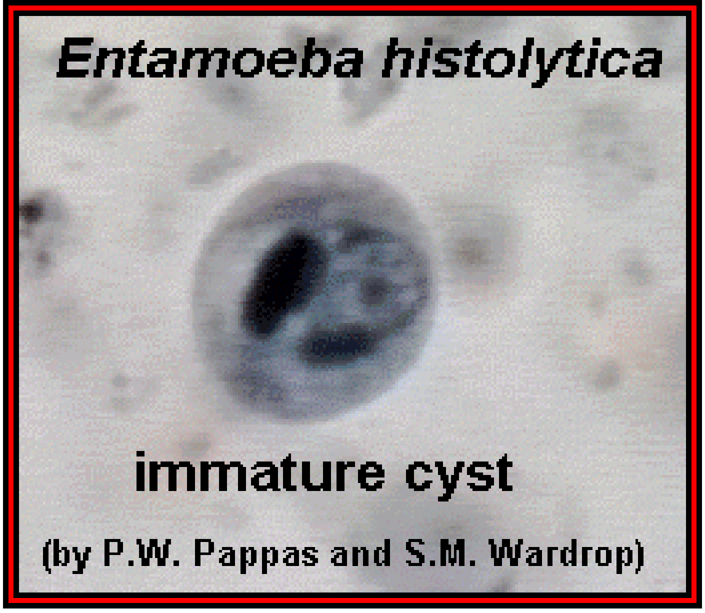
Entamoeba histolytica trophozoite. The single nucleus with its central endosome and regularly distributed chromatin is visible; approximate size = 22 µm.



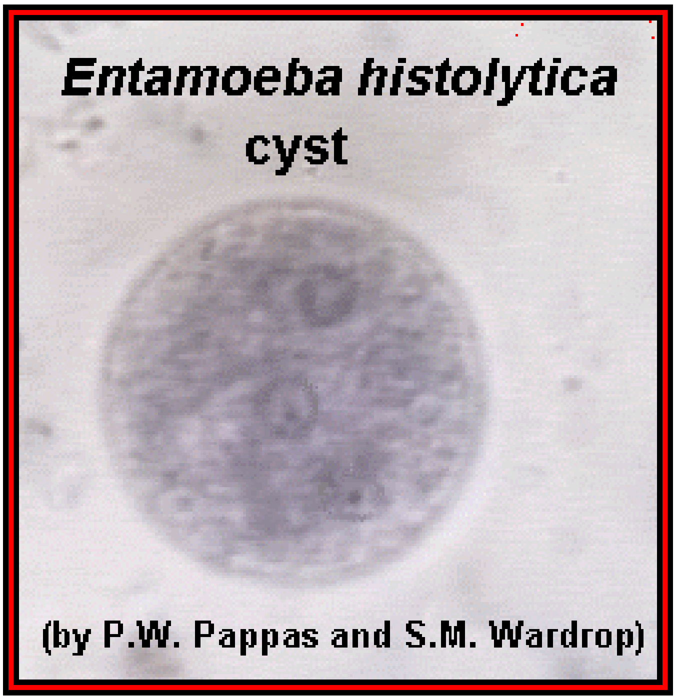
Entamoeba histolytica trophozoite. The single nucleus with its central endosome and regularly distributed chromatin is visible; approximate size = 22 µm.



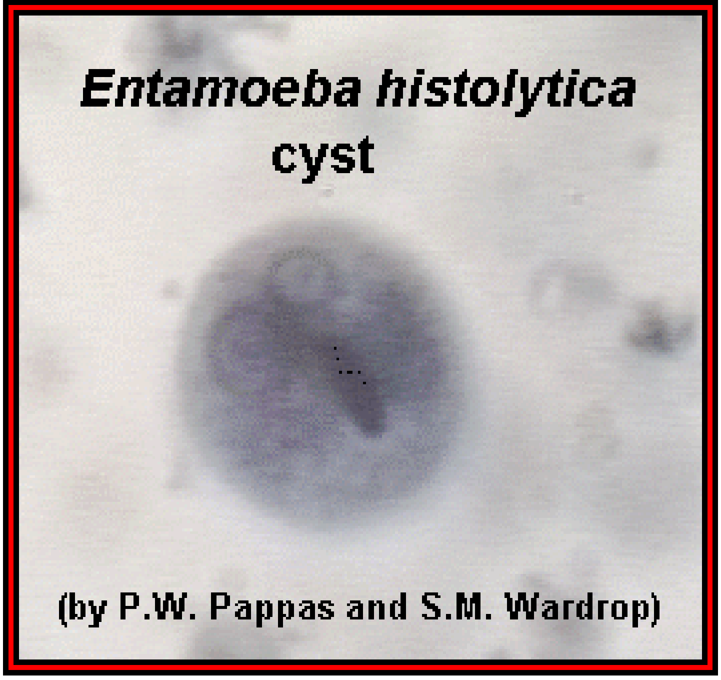
Two very good examples of *Entamoeba histolytica* trophozoites.



An immature cyst of *Entamoeba histolytica*. The single nucleus with its central endosome and regularly distributed chromatin is visible. The dark "rods" in the cytoplasm are the chromatoid bars; approximate size = 18 µm.



A cyst of *Entamoeba histolytica*. This is a mature cyst and, therefore, contains four nuclei. However, only two nuclei are clearly visible in this plane of focus; approximate size = 18 µm.



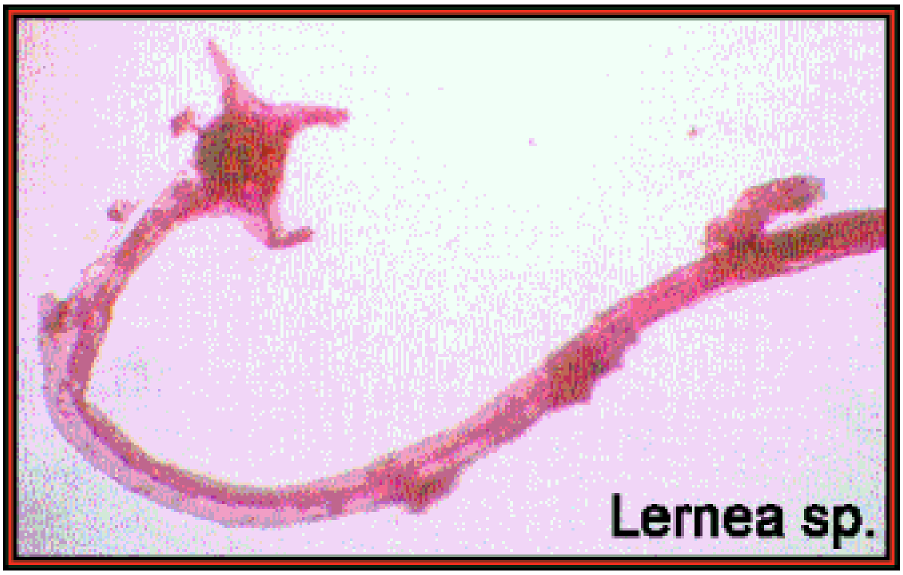
Another cyst of *Entamoeba histolytica*. This is a mature cyst and contains four nuclei. However, only two nuclei are visible in this plane of focus, and a chromatoid bar is still present; approximate size = 17 µm.

Lernea sp.

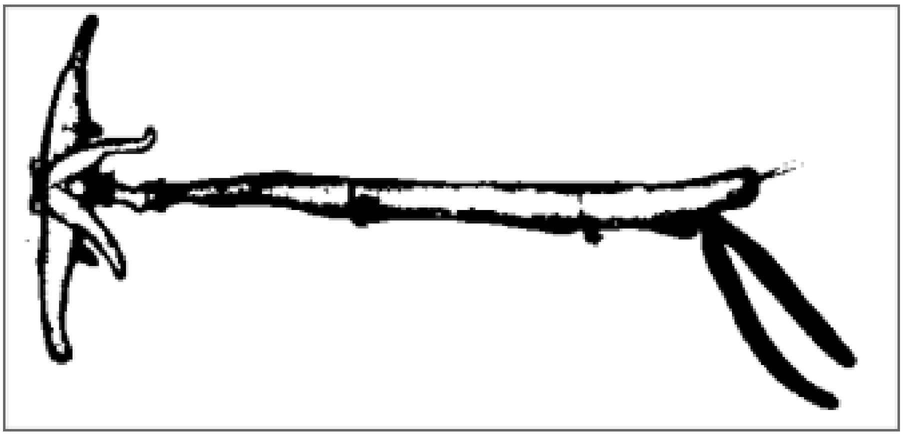
("anchor worms")

Members of this genus of parasitic copepods are highly specialized morphologically. At first glance, they do not even resemble a copepod. The life cycle form seen most often, the parasitic female, is long and slender, and the anterior end is highly modified. No appendages are visible, although egg cases are easily seen.

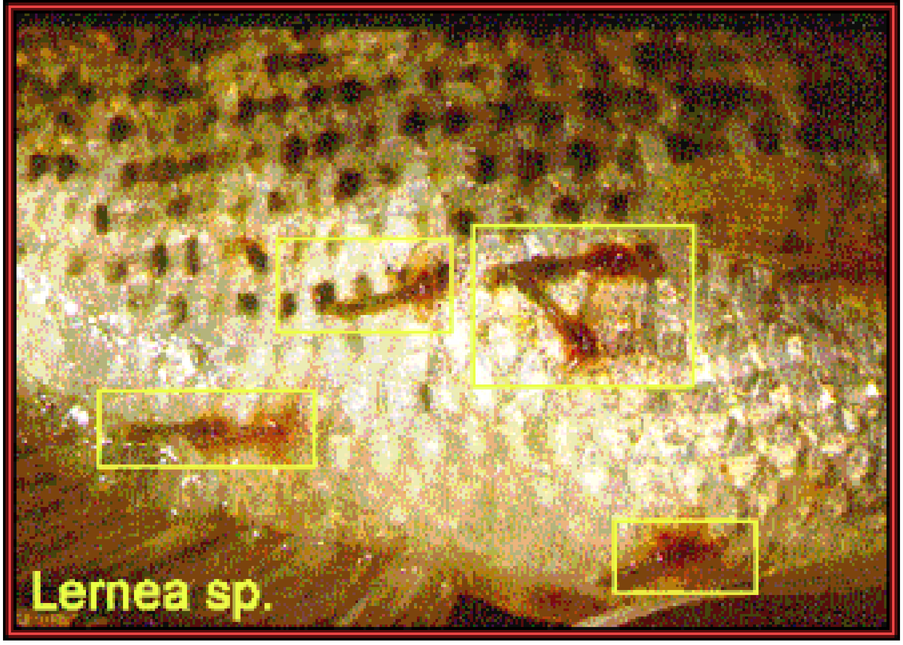
These parasites get the name "anchor worms" because the female's anterior end is embedded or anchored in the host's flesh. These parasites infect a number of aquatic teleosts, and the infections can result in large lesions that can become infected with bacteria or fungi. These parasites are important pests of many commercially important fish, and infections of small fish may be lethal.



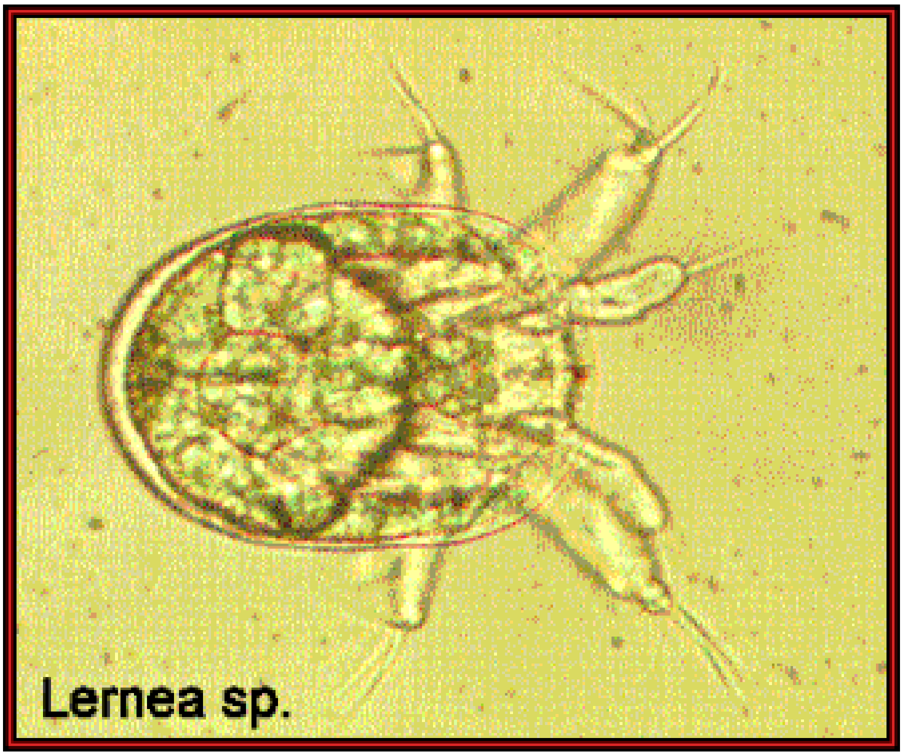
A female *Lernea* (probably *L. cyprinacea*) from rock bass. These parasites can measure up to 12 mm in length.



A line drawing an an entire female *Lernea cyprinacea*. The head or "anchor" is at the left.



Lernea (probably *L. cyprinacea*) attached to the external surface of a bass (yellow rectangles). The hemorrhages associated with such an infection are evident.



As copepods, members of this genus undergoes development similar to free living copepods. The above is an advanced nauplius stage.

Graphic Images of Parasites

Ancylostoma spp. and *Necator* spp.

(hookworms)

There are many species of hookworms that infect mammals. The most important, at least from the human standpoint, are the human hookworms, *Ancylostoma duodenale* and *Necator americanus*, which infect an estimated 800,000,000 persons, and the dog and cat hookworms, *A. caninum* and *A. braziliense*, respectively. Hookworms average about 10 mm in length and live in the small intestine of the host. The males and females mate, and the female produces eggs that are passed in the feces. Depending on the species, female hookworms can produce 10,000-25,000 eggs per day. About two days after passage the hookworm egg hatches, and the juvenile worm (or larva) develops into an infective stage in about five days. The next host is infected when an infective larva penetrates the host's skin. The juvenile worm migrates through the host's body and finally ends up in the host's small intestine where it grows to sexual maturity. The presence of hookworms can be demonstrated by finding the characteristic eggs in the feces; the eggs can not, however, be differentiated to species (view diagram of the life cycle).

The mouthparts of hookworms are modified into cutting plates. Attachment of hookworms to the host's small intestine causes hemorrhages, and the hookworms feed on the host's blood. Hookworm disease can have devastating effects on humans, particularly children, due to the loss of excessive amounts of blood.

Juveniles (larvae) of the dog and cat hookworms can infect humans, but the juvenile worms will not mature into adult worms. Rather, the juveniles remain in the skin where they continue to migrate for weeks (or even months in some instances). This results in a condition known as "cutaneous" or "dermal larval migrans" or "creeping eruption." Hence the importance of not allowing dogs and cats to defecate indiscriminately.

The following image provides an excellent example of how hookworms are attached to and embedded in the epithelium of the host's gastrointestinal tract.

A histological section of a hookworm in the host's small intestine. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

View Images of Hookworm Adults

View Images of Hookworm Eggs

Graphic Images of Parasites

Angiostrongylus cantonensis

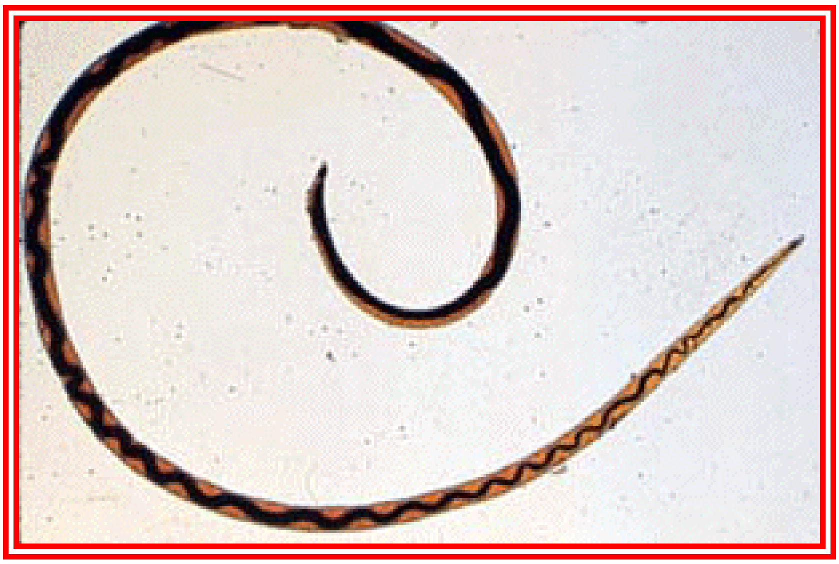
When discovered initially in 1944, *Angiostrongylus cantonensis* was thought to be a parasite of only rodents and, therefore, attracted little attention. However, a few years after its discovery in rodents, this nematode was found in the brain of a teenager in Taiwan, and it has since been found in humans in Hawaii, Tahiti, the Marshall Islands, New Caledonia, Thailand, Vanuatu, the Loyalty Islands, Cuba, and even in Louisiana. The true geographic distribution of this parasite remains unknown.

In the rodent host the adult worms live in the lungs. The females produce eggs which hatch in the lungs, and the first stage larvae (or juveniles) enter the respiratory tract. From here the juveniles migrate up the trachea, and they are then swallowed and passed in the host's feces. This parasite requires an intermediate host to complete its life cycle, most often a slug or an aquatic or a marine snail. The first stage larvae actively penetrate the intermediate host's body, and they molt twice into third stage, infective juveniles. The definitive (rodent or human) host is infected when it ingests an intermediate host containing infective juveniles.

When the rodent host ingests an infected intermediate host, the infective juveniles are liberated, they penetrate the tissues of the gut, and they enter the portal circulation. From here the eventually end up in the host's brain. Following two more molts, the adults migrate back to the host's lungs via the venous circulation. In humans, the parasites enter the brain but do not develop further - the larvae die.

The presence of juveniles in the blood vessels, meninges, or tissue of the human brain can result in symptoms such as headache, fever, paralysis, and even coma. Because of the non-specific nature of these symptoms, angiostrongyliasis is difficult to differentiate from other infections that might involve the brain, including hydatid disease, cysticercosis, strongylodiasis, and visceral larval migrans. The presence of worms is often associated with eosinophilia, and in areas where *A. cantonensis* is endemic, this parasite is probably a primary cause of eosinophilic meningoencephalitis.

(Reference: Roberts, L.S., and Janovy, J., Jr. (1996) *Foundations of Parasitology,* 5th ed. Wm. C. Brown, Publishers.)



An adult *Angiostrongylus cantonensis*. (Original image from the Department of Parasitology, Chiang Mai University, and used with permission.)

The African Giant Snail, an intermediate host for *Angiostrongylus cantonensis*. (Original image from the Department of Parasitology, Chiang Mai University, and used with permission.)

Anisakis spp.

Members of the genus *Anisakis* (and a number of related genera) are parasites of the gastrointestinal tracts (the stomach most often) of marine mammals. The parasites pass eggs in the host's feces, and the eggs are ingested by a crustacean. The juvenile in the egg hatches and matures into an infective juvenile in the crustacean. The definitive host is infected in one of two ways. Some hosts are probably infected when they ingest infected crustaceans. However, if a fish eats the infected crustacean the juveniles will burrow into the tissues of the fish and remain there until the fish is eaten by a definitive host. Considering that most marine mammals eat fish, this mechanism probably accounts for many of the infections. You can view a generalized life cycle for members of the Anisakidae here.

Although this is a parasite of marine mammals, it can have an impact on humans in two ways. One way is when humans find "worms" in the flesh of fish they have either caught or purchased at a market. Although thorough cooking would kill the parasites, many people could not "stomach" the idea of eating a fish they know to contain "worms." Local residents have brought fish to my lab after they have found "worms" in it, and in some cases the worms were still moving even after the fish had been "cooked" (obviously, not long enough). Although these nematodes were not identified, it is likely that some of them belonged to the genus *Anisakis*. How often are market fish infected with such parasites? It depends on many factors, but it is probably fairly common. Just don't look too carefully at the fish you buy, and cook it thoroughly. The dead parasites are just "extra protein."

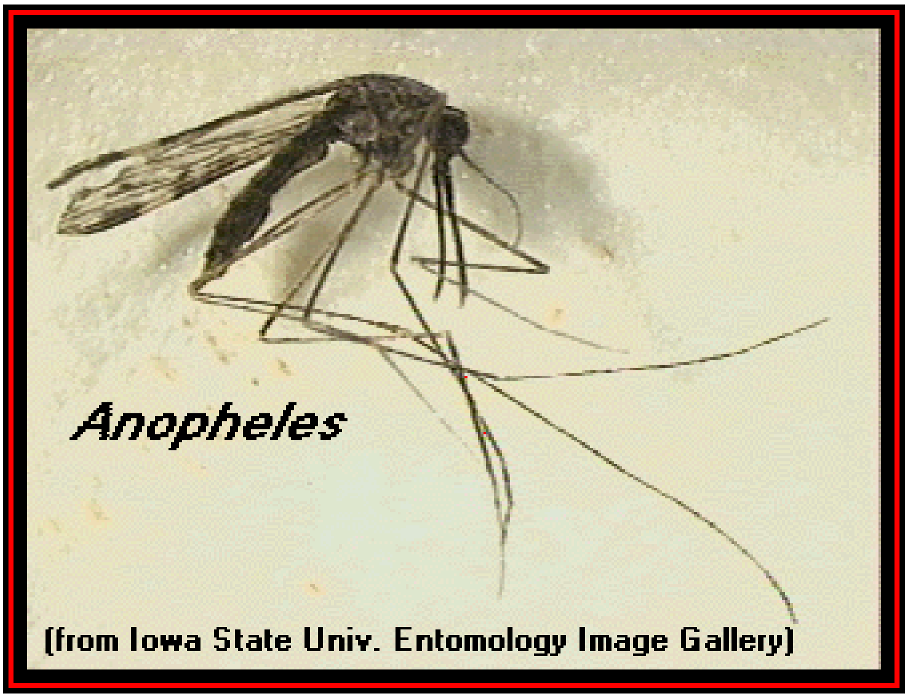
The other way in which this parasite can affect humans is when the human ingests living juveniles that might be in fresh, pickled, or even salted fish. This can result in gastric or intestinal anisakiasis. Such infections can be asymptomatic, or the parasites can cause acute gastrointestinal distress, including acute pain, nausea, and vomiting. Cases have been reported in which the parasites have penetrated the small intestine, resulting in fatal peritonitis. As noted above, cooking will kill the juveniles, as will freezing. However, a number of culinary delights, such as sushi and sashimi, contain raw fish, and such delicacies will continue to be a source of human infections.

Graphic Images of Parasites

Anopheles spp.
(mosquitos)

Of the insects that serve as vectors for parasitic diseases, this genus is arguably the most important. Of the approximately 400 species of *Anopheles*, about two dozen serve as vectors for malaria (*Plasmodium* spp.) in humans. Mosquitos also serve as the vector for canine heart worm (*Dirofilaria immitis*).

Anopheles sp.

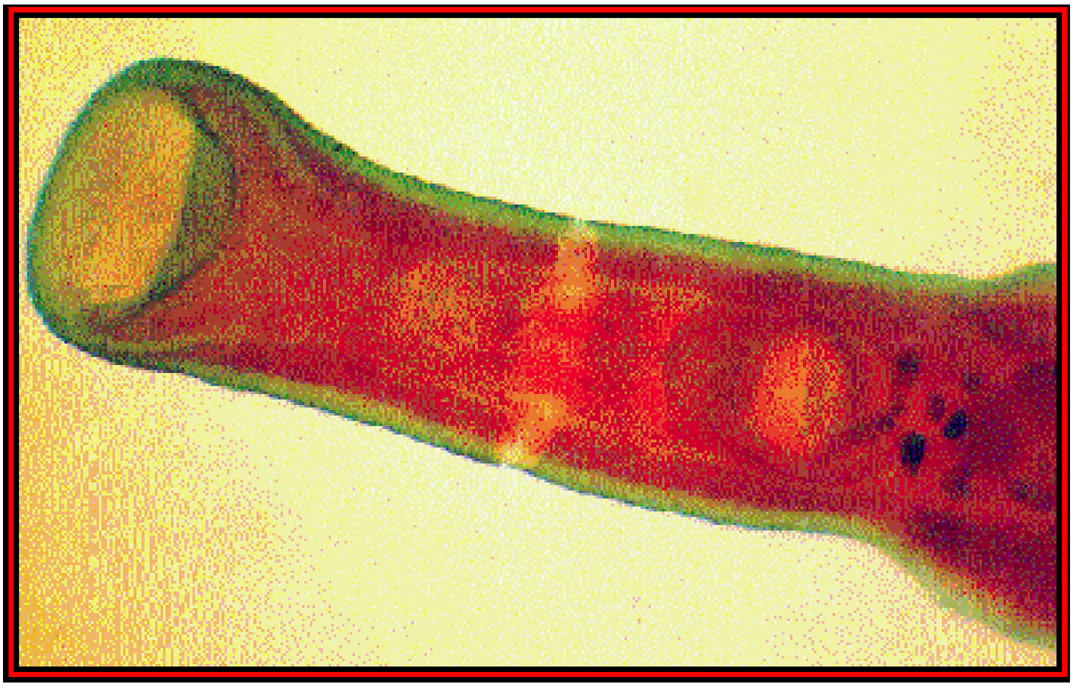


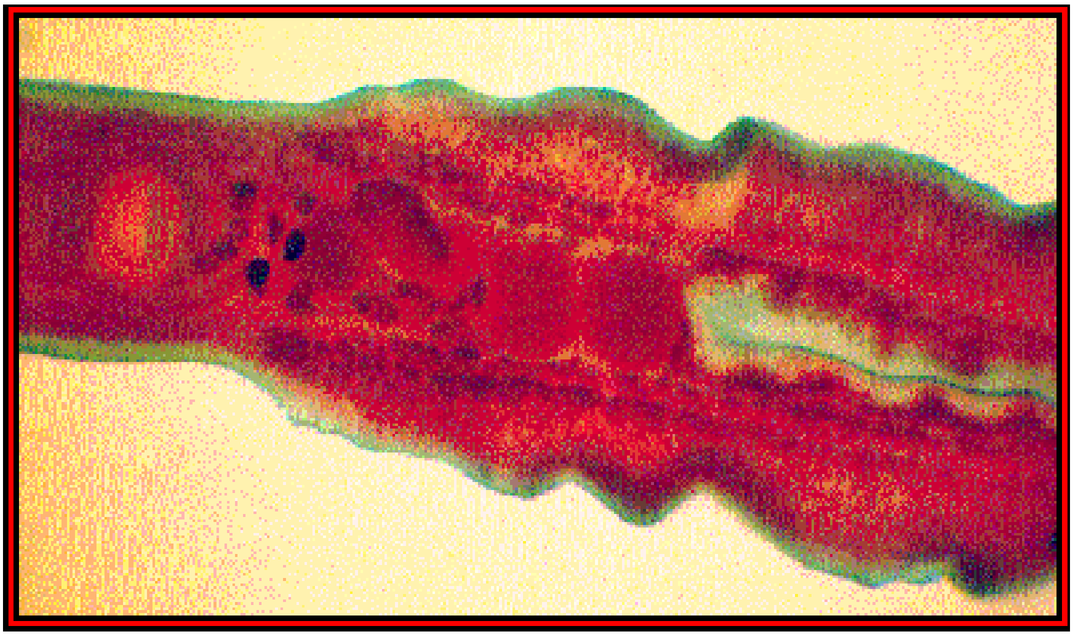
Another example of *Anopheles* sp.

A female mosquito (unknown species) "taking" a blood meal from a human. Note that the female's gut in filled with blood. (Original image from BIODIDAC.)

Apocreadium sp.

The three images below are from a single specimen of *Apocreadium cryptium*. The top, middle, and bottom images represent the anterior, middle, and posterior sections of the trematode. The extended anterior end (what looks like a "snout") is an artifact.

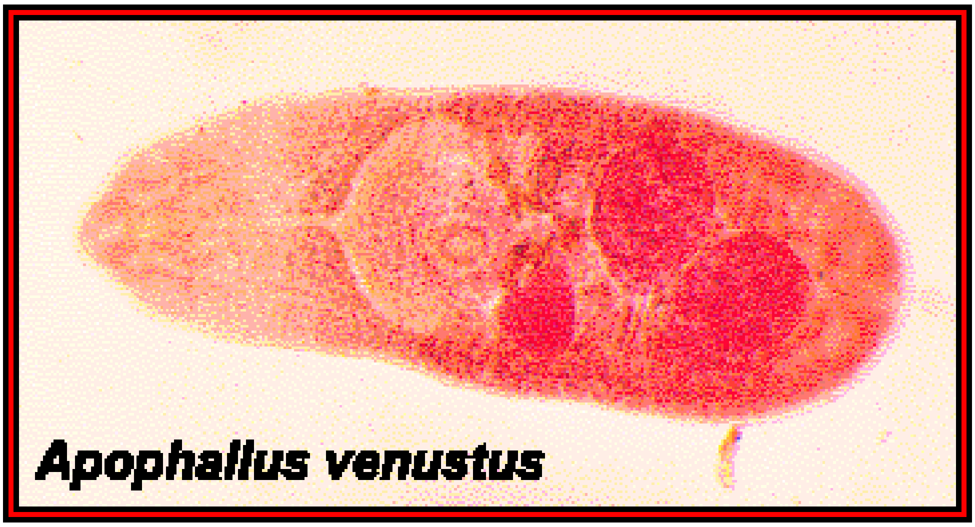




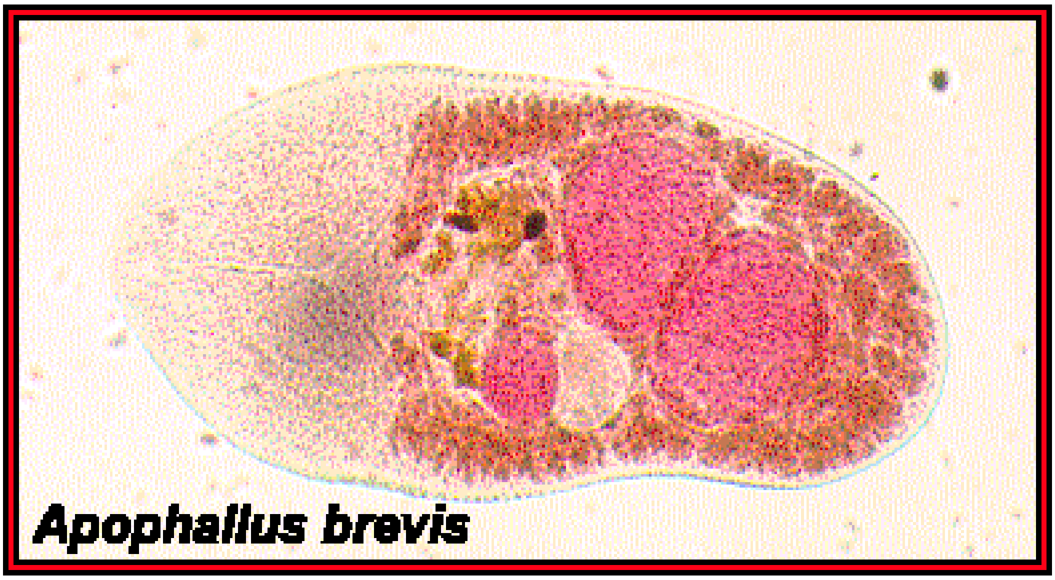
Graphic Images of Parasites

Apophallus sp.

The life cycle of *Apophallus venustus* involves herons, dogs, cats, or raccoons as the definitive host. Snails, such as *Goniobasis livescens*, serve as the first intermediate host, and fish serve as the second intermediate host. In *A. brevis*, *Amnicola limosa* is the first intermediate host, trout are the second intermediate host, and birds are the definitive host.



Apophallus venustus recovered from a gull.



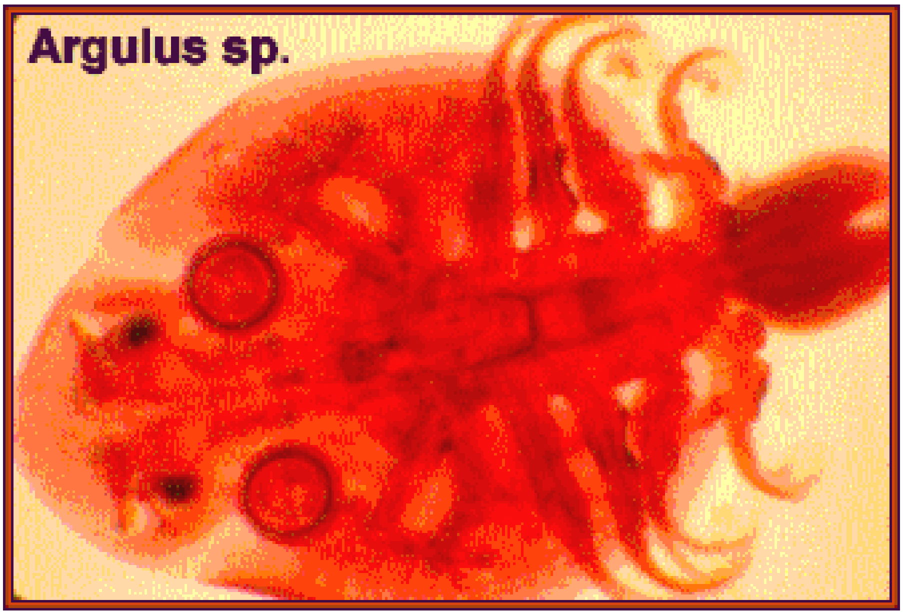
Apophallus brevis recovered from a herring gull.

Argulus sp.

"The most common members of the Branchiura belong to the genus *Argulus* and are commonly referred to as 'fish lice.' Many of the species are parasitic on marine fishes, and some fifteen are found on freshwater fishes. At least one species has been reported on an amphibian."

"The mouthparts of *Argulus* are greatly reduced, and the most striking feature is the modification of the second maxillae into two suction cups by which the parasite holds onto its host. *Argulus* also possesses a preoral sting by which the animal pierces its host in order to obtain the required blood meal. When seen from the dorsal aspect, two prominent movable compound eyes are visible in the head region."

(Reference: Cheng, T.C. (1973), *General Parasitology*, Academic Press, N.Y.)

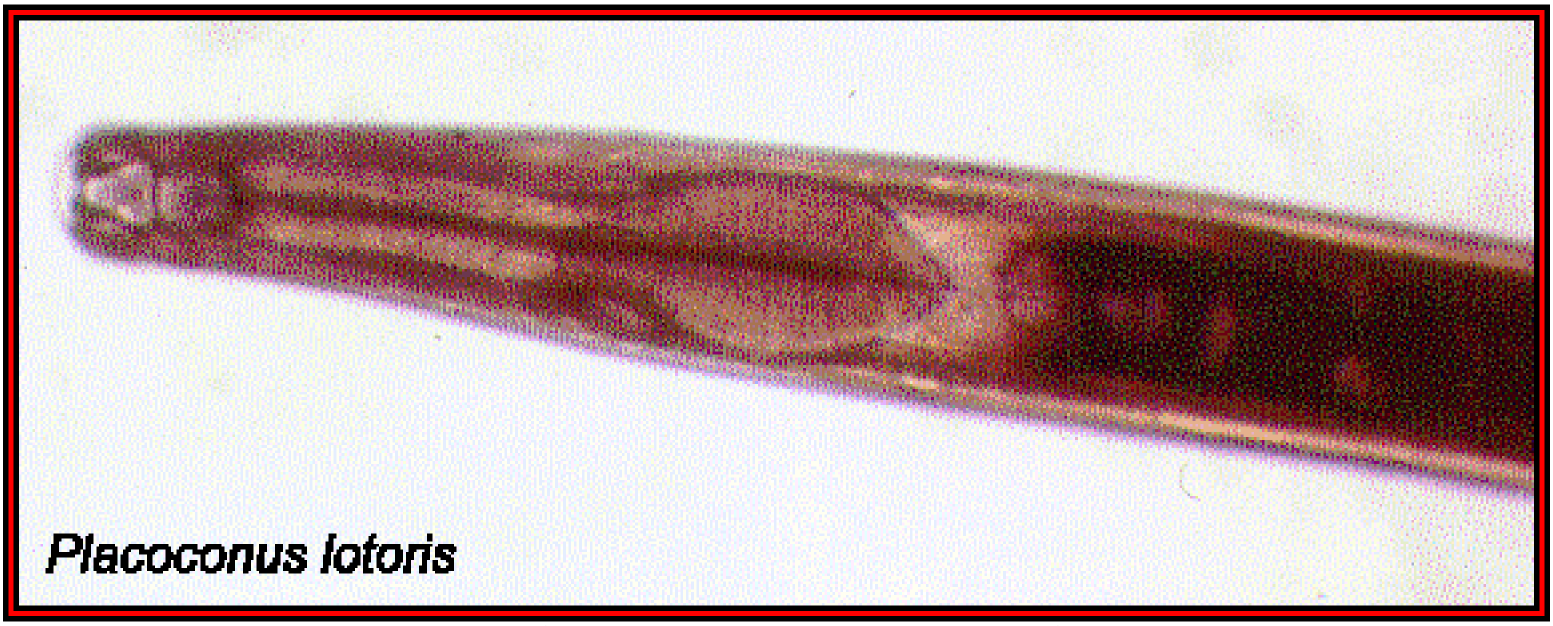


A stained whole mount of *Argulus* sp. The four pairs of thoracic swimming legs and the two "suction cups" are visible in this preparation.

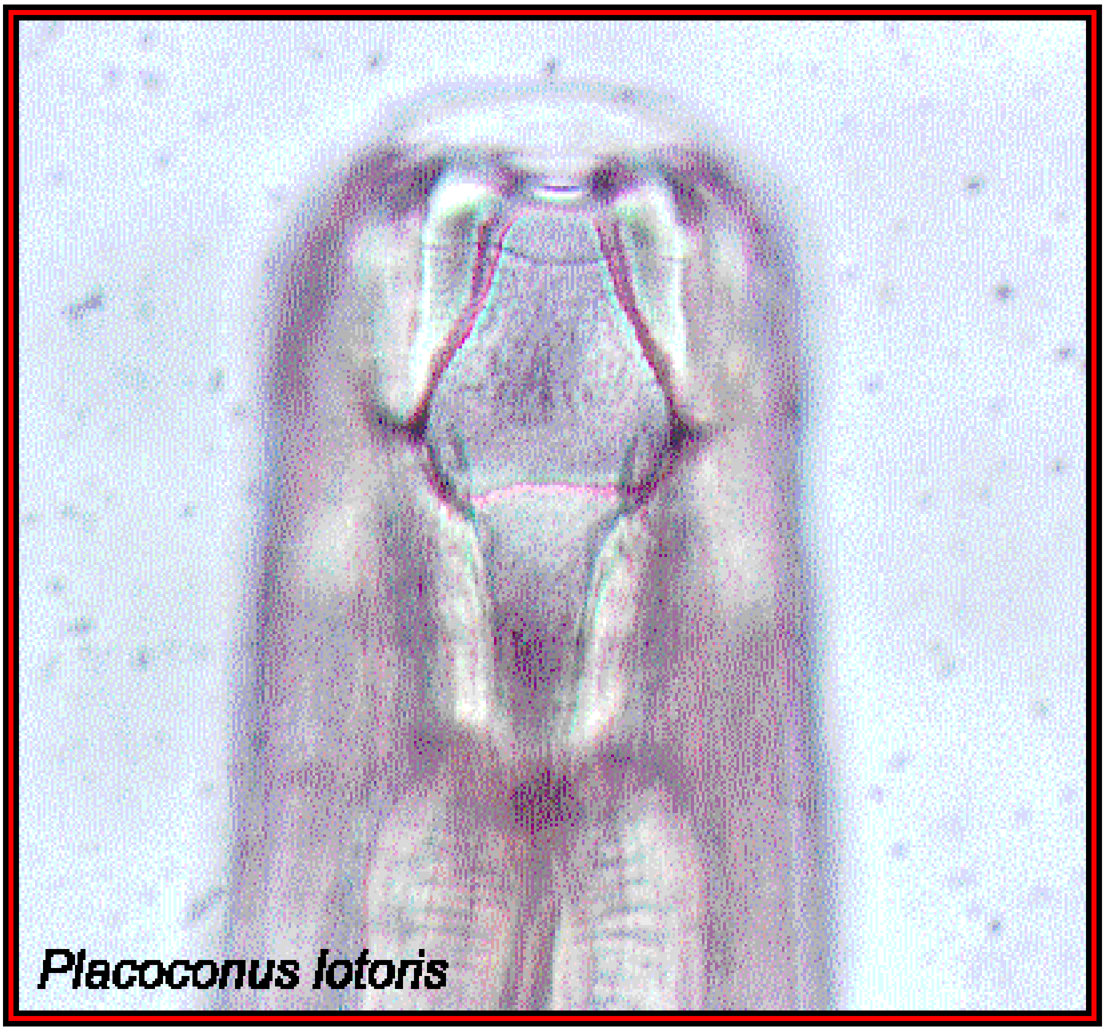
An enlargement of the anterior end of the specimen shown above. Note the two compound eyes (dark spots).

Graphic Images of Parasites

Placoconus (= Arthrocephalus) sp.



The anterior end of an adult *Placoconus lotoris* recovered from a raccoon.



An higher power view of the anterior end of *Placoconus lotoris* showing the well developed cutting plates of the buccal

cavity.

Ascaris lumbricoides and *Ascaris suum*
(intestinal roundworms of humans and pigs)

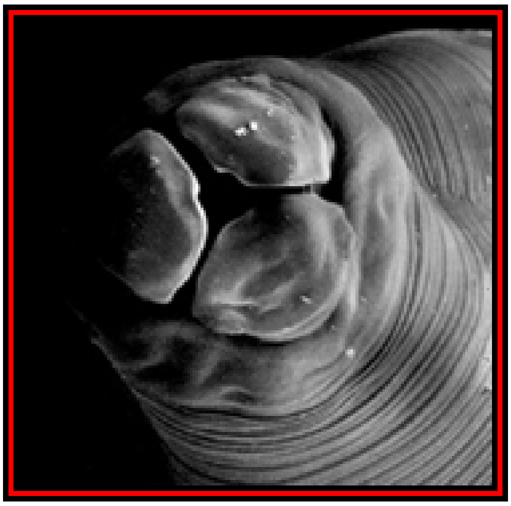
Ascaris lumbricoides is one of the largest and most common parasites found in humans. The adult females of this species can measure up to 18 inches long (males are generally shorter), and it is estimated that 25% of the world's population is infected with this nematode. The adult worms live in the small intestine and eggs are passed in the feces. A single female can produce up to 200,000 eggs each day! About two weeks after passage in the feces the eggs contain an infective larval or juvenile stage, and humans are infected when they ingest such infective eggs. The eggs hatch in the small intestine, the juvenile penetrates the small intestine and enters the circulatory system, and eventually the juvenile worm enters the lungs. In the lungs the juvenile worm leaves the circulatory system and enters the air passages of the lungs. The juvenile worm then migrates up the air passages into the pharynx where it is swallowed, and once in the small intestine the juvenile grows into an adult worm. Why *Ascaris* undergoes such a migration through the body to only end up where it started is unknown. Such a migration is not unique to *Ascaris*, as its close relatives undergo a similar migration in the bodies of their hosts (view diagram of the life cycle).

Ascaris infections in humans can cause significant pathology. The migration of the larvae through the lungs causes the blood vessels of the lungs to hemorrhage, and there is an inflammatory response accompanied by edema. The resulting accumulation of fluids in the lungs results in "ascaris pneumonia," and this can be fatal. The large size of the adult worms also presents problems, especially if the worms physically block the gastrointestinal tract. *Ascaris* is notorious for its reputation to migrate within the small intestine, and when a large worm begins to migrate there is not much that can stop it. Instances have been reported in which *Ascaris* have migrated into and blocked the bile or pancreatic duct or in which the worms have penetrated the small intestine resulting in acute (and fatal) peritonitis. *Ascaris* seems to be especially sensitive to anesthetics, and numerous cases have been documented where patients in surgical recovery rooms have had worms migrate from the small intestine, through the stomach, and out the patient's nose or mouth.

Ascaris suum is found in pigs. Its life cycle is identical to that of *A. lumbricoides*. If a human ingests eggs of *A. suum* the larvae will migrate to the lungs and die. This can cause a particularly serious form of "ascaris pneumonia." Adult worms of this species do not develop in the human's intestine. (Some parasitologists believe that there is but one species of *Ascaris* that infects both pigs and humans, but any commentary on this issue is beyond the scope of this web site.)

Infections of *Ascaris* are diagnosed by finding characteristic eggs in the feces of the infected host.

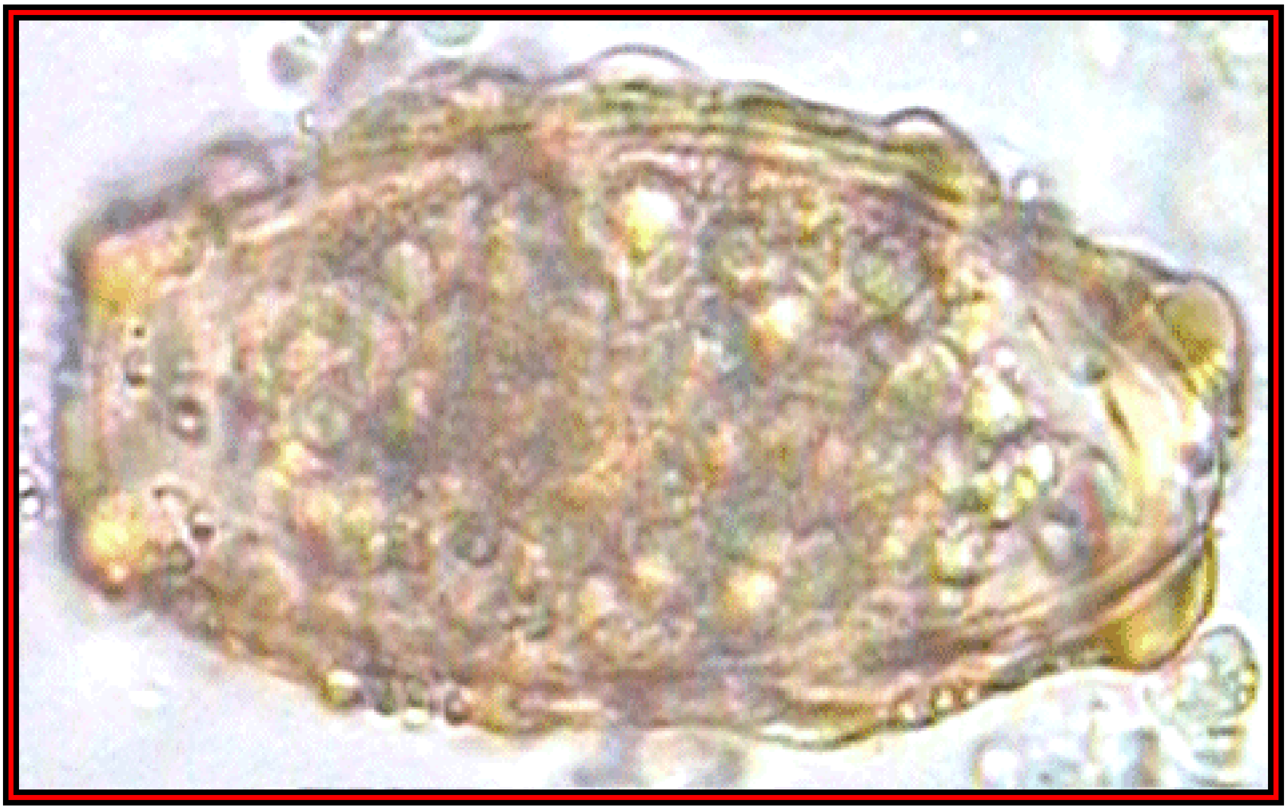
An *en face* view of *Ascaris*. Note the presence of three large lips, a characteristic of all ascarids. (Original image from Oklahoma State University, College of Veterinary Medicine.)



A scanning electron micrograph of the anterior end of *Ascaris* showing the three prominent "lips." (Original image from "Wormland".)

Ascaris lumbricoides, fertilized egg. Note that the egg is covered with a thick shell that appears lumpy (bumpy) or mammillated; approximate size = 65 µm in length.


Another example of a fertilized *Ascaris lumbricoides* egg. (Original image from: Atlas of Medical Parasitology.)

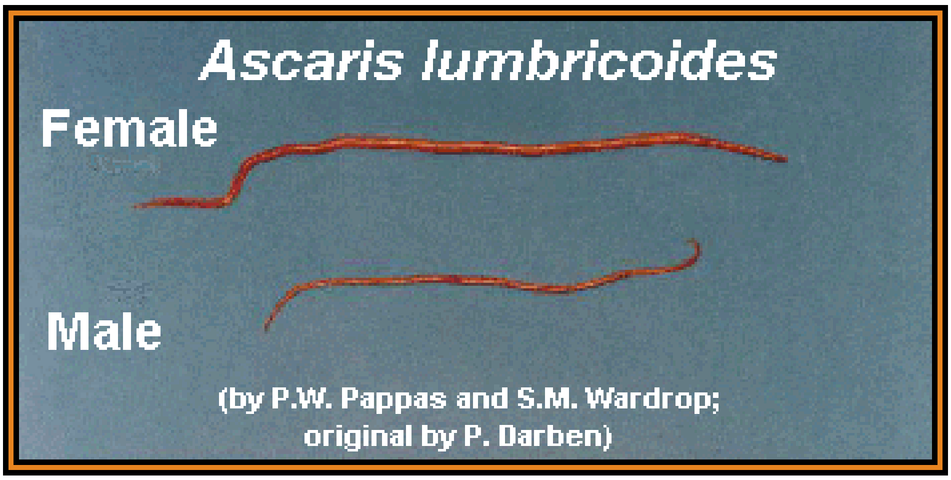


An example of an unfertilized *A. lumbricoides* egg. (Original image from: Atlas of Medical Parasitology.)

A "decorticated," fertilized, *Ascaris lumbricoides*. (Original image from: Atlas of Medical Parasitology.)

Eggs of *Ascaris suum*. *A. suum* is a common parasite of pigs. The eggs are virtually indistinguishable from those of *A. lumbricoides*. (Original image from [Oklahoma State University, College of Veterinary Medicine](#).)

A female *Ascaris lumbricoides*. Females of this species can measure over 16 inches long. This specimen was passed by a young girl in Florida. (Original image from [DPDx [Identification and Diagnosis of Parasites of Public Health Concern]](#).)



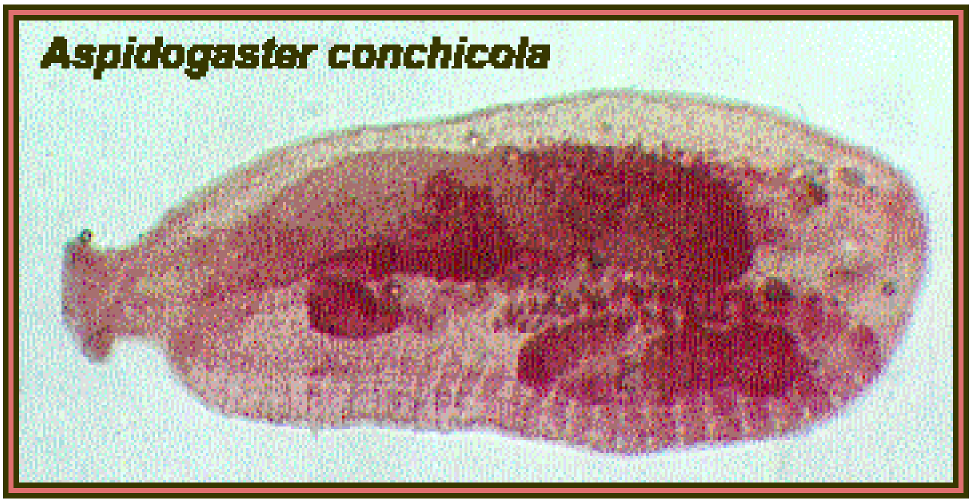
Female and male *Ascaris lumbricoides*; the female measures approximately 16 inches (40 cm) in length.

A large mass of *Ascaris lumbricoides* that was passed from the intestinal tract. The ruler at the bottom of the image is 4 cm (about 1.5 inches) in length.

Aspidogaster sp.

The best known representative of this genus is *Aspidogaster conchicola*. This organism occurs in the pericardial and renal cavities of clams. It occasionally infects snails, and other animals even less often. The life cycle is direct, with the parasites producing eggs that are liberated via the host's siphon. The eggs hatch in water, and a new host is infected when larvae are drawn in via the incurrent water siphon. Once in the host the immature parasite migrates to the pericardial or renal cavity and grows to sexual maturity.

A whole mount of *Aspidogaster* sp. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

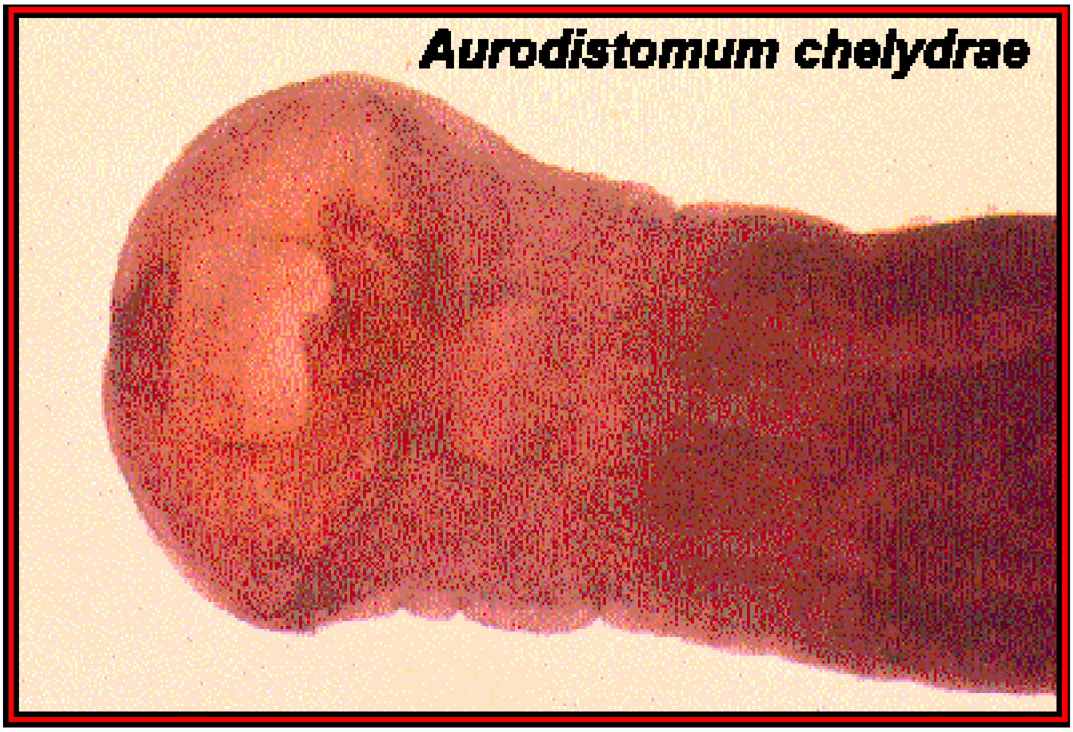


A whole mount of *Aspidogaster conchicola*.

A histological section of *Aspidogaster conchicola* in the pericardium of a clam.

Auridistomum chelydrae

The adults of this parasite are found in the small intestines of turtles. The eggs are passed in the feces, and the first intermediate host is a snail (e.g., *Helisoma*). Cercariae are liberated from the snail and encyst in tadpoles, and turtles are infected when they eat infected tadpoles.

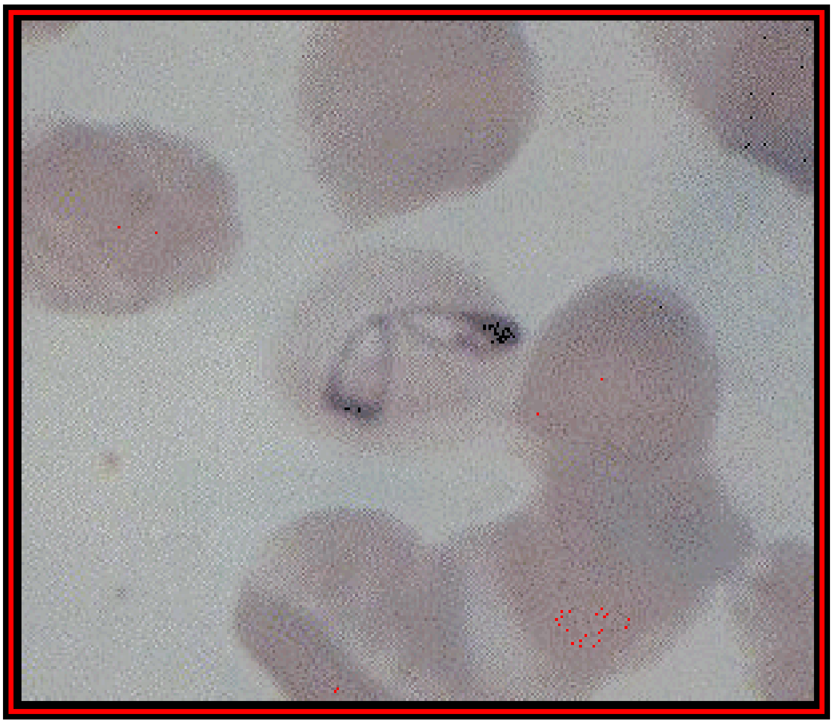


Graphic Images of Parasites

Babesia sp.
(babesiosis)

Members of the genus *Babesia* belong to a group of the Apicomplexa referred to as the "piroplasms." The piroplasms have two host life cycles involving a tick and mammal. In the mammalian host the organisms reproduce asexually in the host's red blood cells.

The vector for *Babesia bigemina* is a hard tick (*Boophilus* sp.), and the parasite infects a variety of ruminants. In cattle this parasite causes a disease known as Texas cattle fever or red-water fever. The parasite often occurs in pairs in the host's red blood cells, hence the name "bigemina," and in cattle the parasite can cause massive destruction of the red blood cells. This results in red urine (due to hemoglobin in the urine), and the disease can kill cattle within a week. Related species occur in dogs (*B. canis*) and rodents (*B. microti*). The latter species also occurs in humans, with about 10-15 cases a year being reported.

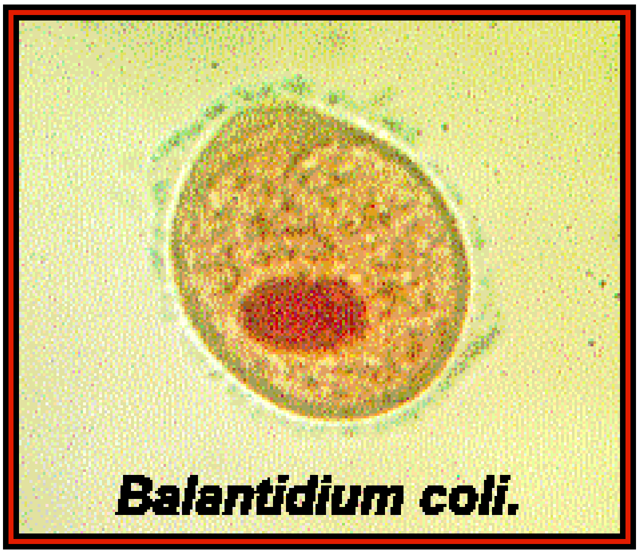


Babesia bigemina in the red blood cell of a cow; note the two parasites in a single red blood cell. (Original graphic from Oklahoma State University, College of Veterinary Medicine.)

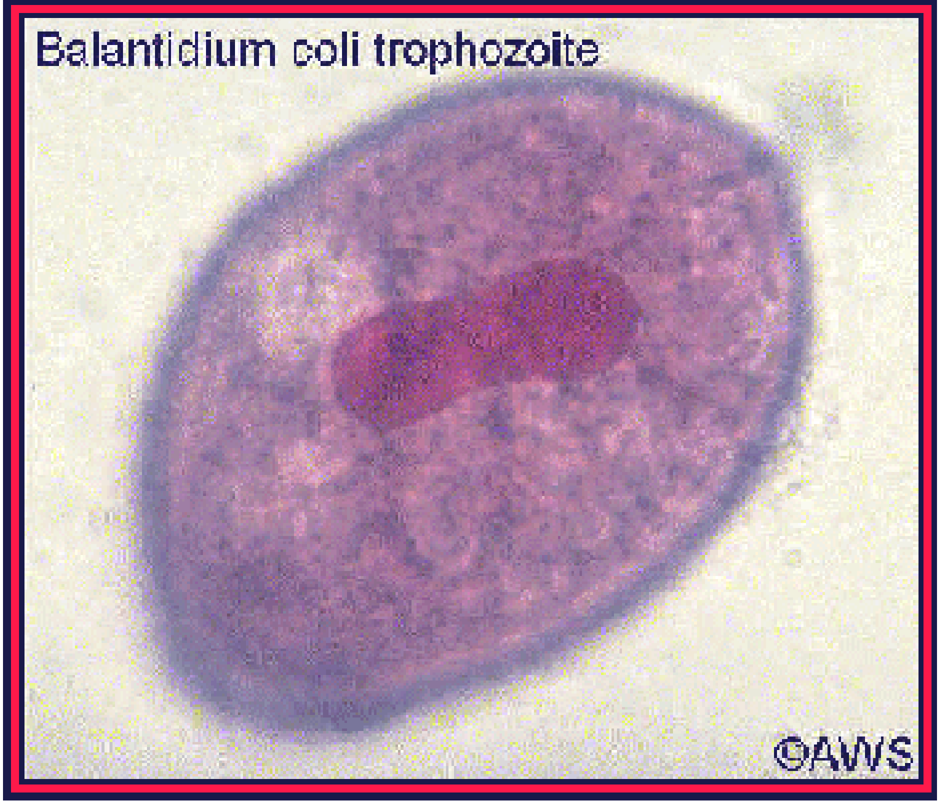
A red blood cell infected with four *Babesia bigemina*.

Balantidium coli

Balantidium coli is a parasite of many species of animals, including pigs, rats, guinea pigs, humans, and many other animals. It appears that the parasite can be transmitted readily among these species, providing the appropriate conditions are met (i.e., fecal contamination). Humans are infected when they ingest cysts via food or water contaminated with fecal material. In many respects this parasite resembles *Entamoeba histolytica* --- an important difference that can have a significant impact of epidemiology is that trophozoites of *B. coli* will encyst after being passed in stools, trophs of *E. histolytica* will not. In humans this parasitic species resides most often in the large intestine, and it can invade the mucosa (or invade lesions caused by other organisms) causing serious pathology. Ectopic (extra-intestinal) infections can also occur. You can view a diagram of the life cycle here.



A trophozoite of *Balantidium coli*.



A trophozoite of *Balantidium coli*; trophozoites average about 75 µm in length. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Histological section showing *Balantidium coli* trophozoites in the intestinal tract. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Baylisascaris procyonis

Baylisascaris procyonis is a common parasite of raccoons. It has been reported in Canada and Europe, and many parts of the United States, and it is likely cosmopolitan in distribution. The life cycle of *B. procyonis* is similar to that of its close relative, *Ascaris* sp. The adult roundworms live in the raccoon's small intestine, eggs are passed in the feces, and it takes approximately one month for the eggs to become infective once passed. The next host is infected when it ingests infective eggs (click here to view a diagram of the life cycle). This parasite causes little if any damage in the raccoon.

Other animals can serve as paratenic hosts for *B. procyonis*, often with devastating results. When the eggs are eaten by a host other than a raccoon, they hatch, and the larvae migrate into the host's tissues. As with infections of paratenic hosts with *Toxocara canis* larvae, an infection with *B. procyonis* larvae is often called visceral larval migrans (VLM), and the outcome of the infection depends on the number of larvae in the host and the tissues affected. The larvae often end up in the host's central nerouvs system (CNS), and the literature contains reports of fatal CNS disease in many species of animals. Humans can be infected with *B. procyonis* larvae. It is impossible to determine how often humans are infected with this parasite since these infections are diagnosed only when the migrating larvae result in obvious symptoms (such as CNS disease), or when they are seen in the host's eye during a routine eye examination.

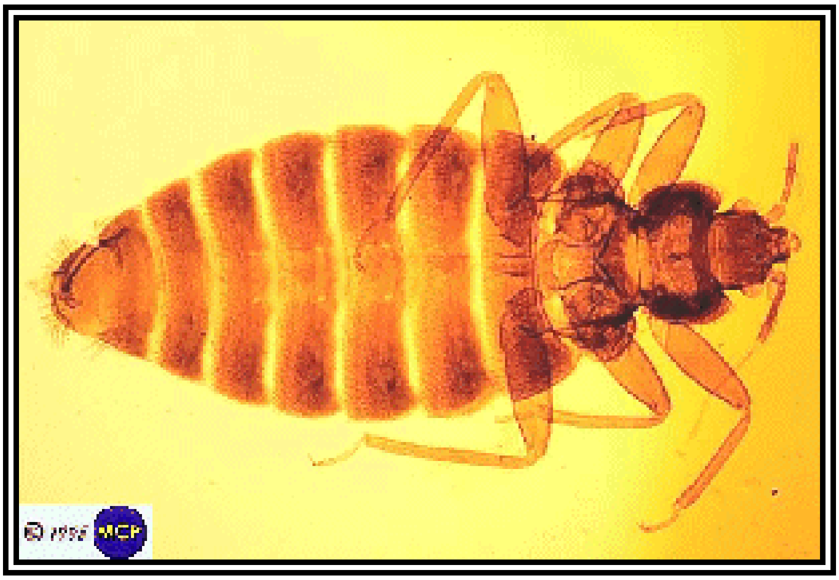
Raccoons are found commonly in many rural and urban areas, and humans often keep them as pets or entice them into their yards by feeding them. This increases the probability that raccoons will defecate in an areas to which humans have access. Moreover, the eggs of *B. procyonis* can remain infective for many months (perhaps years), so it is quite possible for an area to be contaminated with eggs even though there are no obvious signs of raccoon feces. Several fatalities in humans have resulted from infections with *B. procyonis* larvae, so **keeping raccoons as pets or enticing them into your yards is not prudent**.

Cimex spp.
(bedbugs)

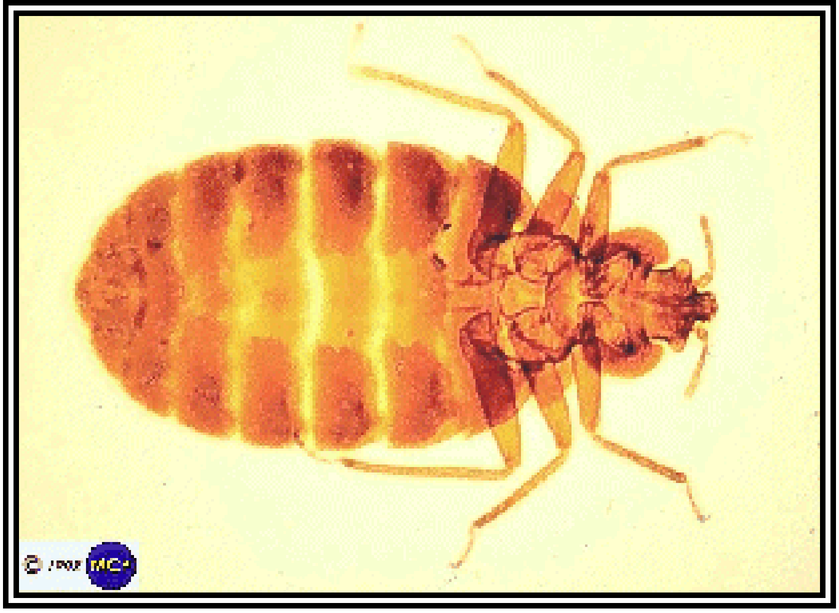
There are approximately seven species of bedbugs that will feed on humans. The most common bedbugs are *Cimex lectularis* (the "human bedbug" with a cosmopolitan distribution), *Cimex hemipterus* (the "tropical bedbug" found most often in tropical climates), and *Leptocimex boueti* (found in W. Africa). Even though bedbugs have many characteristics that would make they excellent vectors for diseases, **bedbugs do not, as far as is known, serve as vectors for any human diseases**. (It has been shown experimentally that many infectious agents can live in bedbugs. However, none of these agents reproduce in the bedbugs, and the bedbugs will not transmit any of these infectious agents).

Bedbugs are small (about 8 mm long), nocturnal creatures, coming out of hiding at night to feed on unsuspecting humans. **They feed exclusively on blood!** Their bites often result in an allergic reaction (a small weal). Some humans tend to react more strongly to bedbug bites (they become sensitized), while others may never react no matter how many times they are bitten. In those instances where infestations are heavy and people are bitten many times, the bites are so annoying that a person will lose considerable sleep, and they may suffer from iron and/or hemoglobin deficiencies due to the lose of blood.

Because of their small size and inconspicuous nature, bedbugs can be transported from one house to another in furniture, clothing, laundry, and a variety of other ways. Once in a house, bedbugs can hide almost anywhere. As one might suspect, they tend to be found around the bed, hiding in the mattress, box springs, and sheets, but they can also be found behind the baseboards, under furniture, and even behind wallpaper. Control of a bedbug infestation requires the careful use of pesticides. One might think that you could "starve" the bedbugs out of your house by simply leaving for a few days. This would, however, prove fruitless, as bedbugs can survive more than a year without feeding.



Cimex hemipterus, the "tropical bedbug." (Original image from [The Veterinary Parasitology Images Gallery, University of São Paulo](), and used with permission.)



Cimex lectularis, the "human bedbug." (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

A bedbug feeding on human skin. This image gives a good indication of the size of bedbugs. (Original image from "Entomology at Clemson University" web site.)

Schistosoma sp.

(schistosomes or blood flukes; schistosomiasis)

The schistosomes are unusual trematodes in that the sexes are separate (they are dioecious), they reside in the blood vessels of the definitive host, and there are no second intermediate hosts in their life cycles. There are a number of species of schistosomes that can infect humans, but most human infections are caused by one of the three following species: *Schistosoma mansoni*; *S. haematobium*; *S. japonicum*. Considering the distributions of all three species, schistosomiasis is distributed throughout almost all of Africa, parts of southeast Asia, parts of northwest South America, and some islands in the Caribbean Sea. It is estimated that approximately 200,000,000 million people are infected with schistosomes, resulting in 1,000,000 deaths each year. The approximate geographic distributions of *S. mansoni* and *S. japonicum* are shown here.

The life cycles of the three primary species of human schistosomes are similar. The male and female worms average about 10 mm in length and live in the veins of the abdominal cavity. Here they mate and the females produce eggs. The adult worms can live 20-30 years and, depending on the species, and each female can produce several hundred eggs each day. The eggs escape from the body by penetrating the walls of the veins and small intestine or urinary bladder, and they are passed in the feces or urine. The eggs hatch in water, the first intermediate host (a snail) is infected, and cercariae are liberated from the snails. When humans come in contact with water containing cercariae, the cercariae penetrate their skin and they become infected. This occurs when the humans swim, bath, wash clothes, etc., in rivers and streams. After the cercariae penetrate the skin the immature worms enter the circulatory system and migrate to the veins of the abdominal cavity, and in about six weeks they reach sexual maturity (view diagram of the life cycle).

As the eggs of the schistosomes penetrate the walls of the veins and the small intestine or urinary bladder, they cause a significant amount of damage to the tissues. The tissues hemorrhage, so blood often appears in the urine or feces. As the infection progresses the tissues become inflamed and fibrotic and unable to function normally. Many of the eggs produced by the female worms do not escape from the veins, but are swept up in the circulatory system and deposited in the host's liver. The liver responds to the presence of the eggs by encapsulating them in a fibrous granuloma. The damage to the small intestine (or urinary bladder) and liver accumulate over time and result in a chronic, disabling disease that can be fatal.

As with most trematode infections, diagnosis most often depends on finding the parasite's eggs. In the case of *S. haematobium*, eggs are most often recovered in the urine; eggs of the other two species are most often recovered in the feces.

View images of schistosome eggs

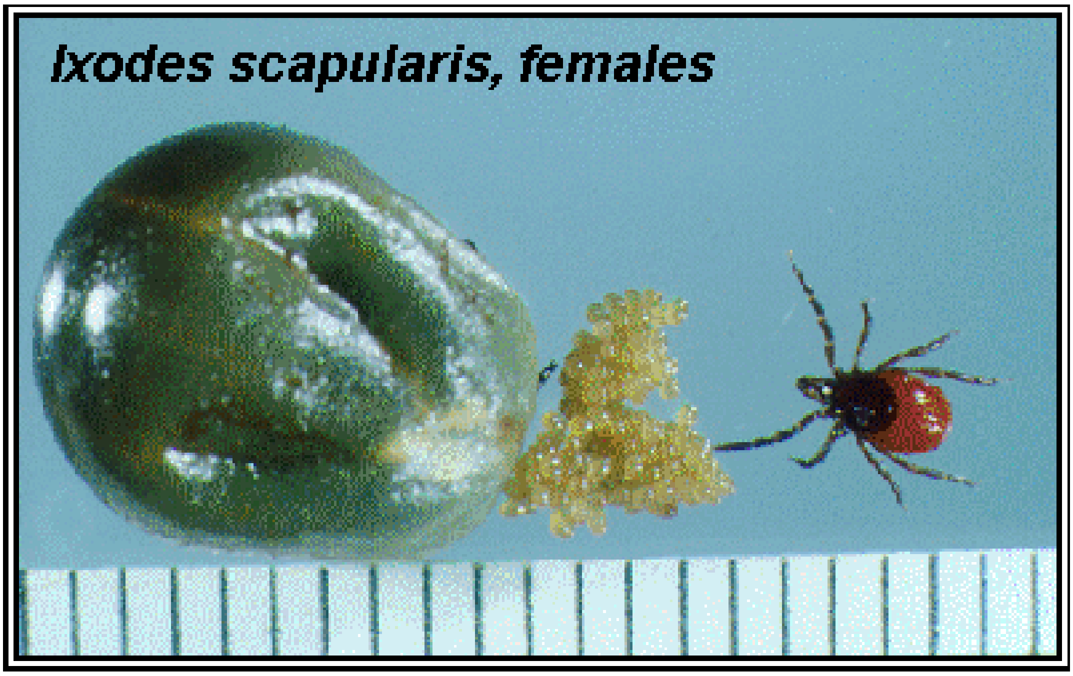
View images of schistosome adults

View images of schistosome pathology

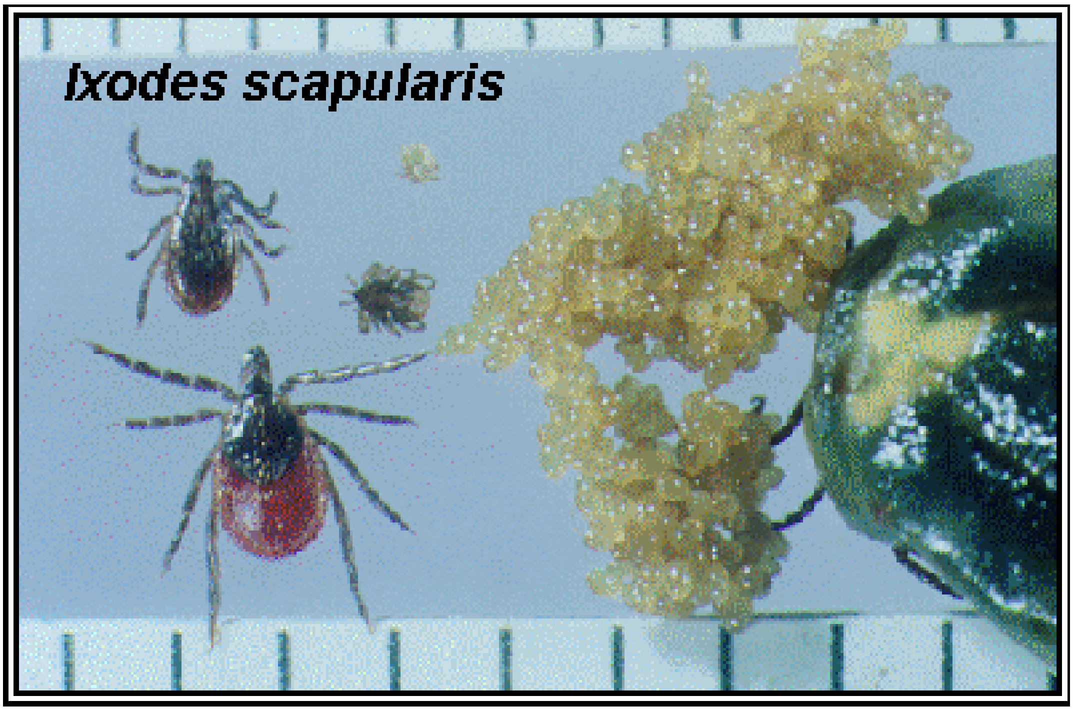
Graphic Images of Parasites

Ixodes scapularis

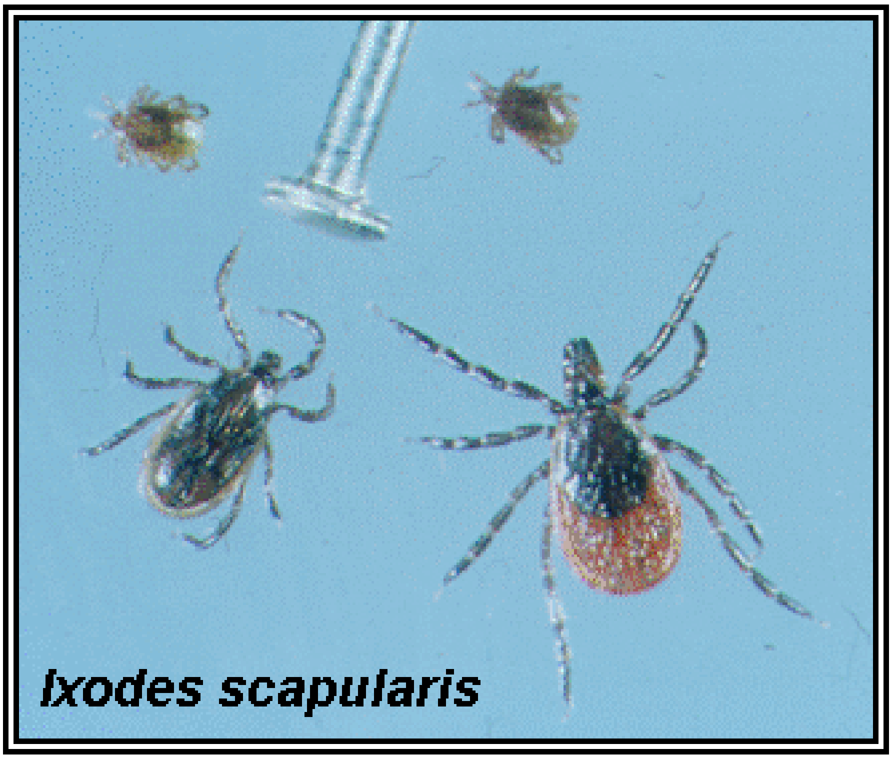
The black-legged tick (*Ixodes scapularis*) is sometimes called the deer tick. There are over 200 species of *Ixodes*, and many of them will transmit Lyme disease to humans.



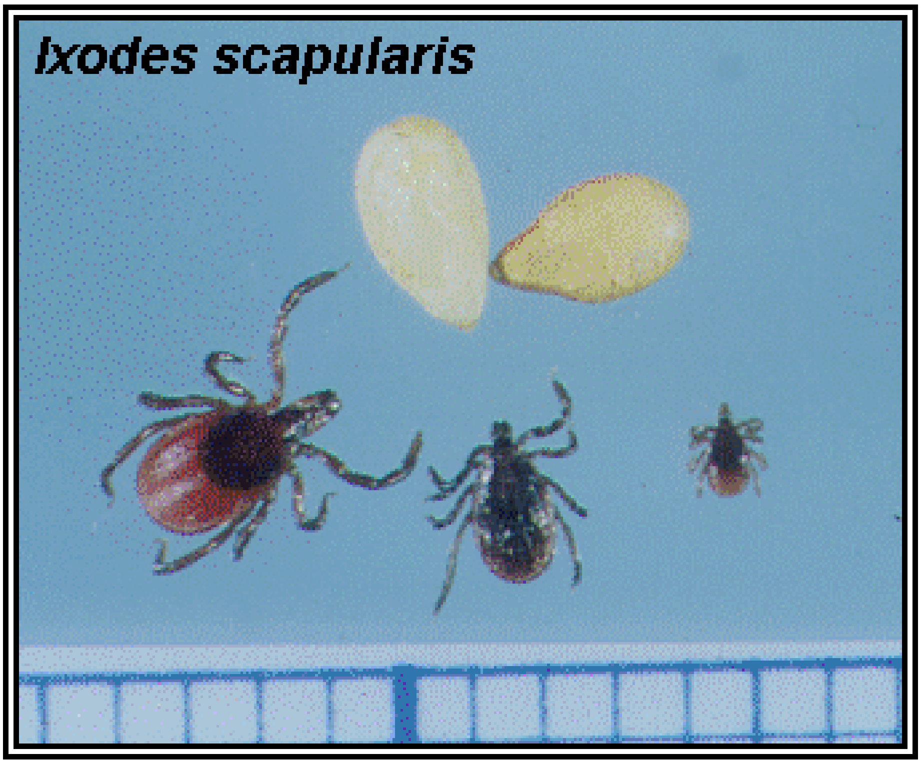
Ovipositing (left) and unengorged (right) females of *Ixodes scapularis*. (Bottom scale in mm.) (Scanned and modified from a transparency provided by Jim Occi.).



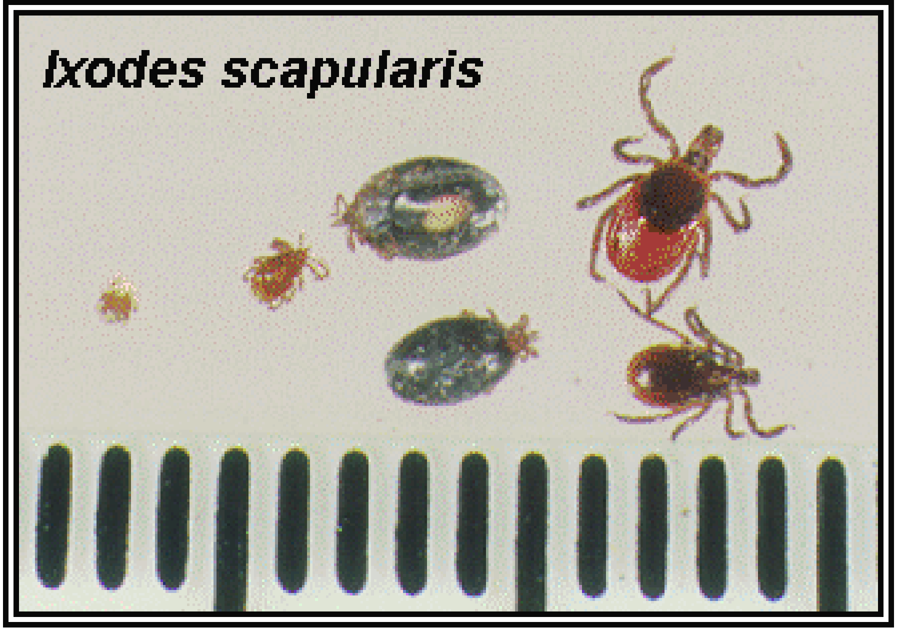
Various life cycle stages of *Ixodes scapularis*. Top left = male; bottom left = female; center = nymph; right = ovipositing female. (Top scale in mm.) (Scanned and modified from a transparency provided by Jim Occi.)



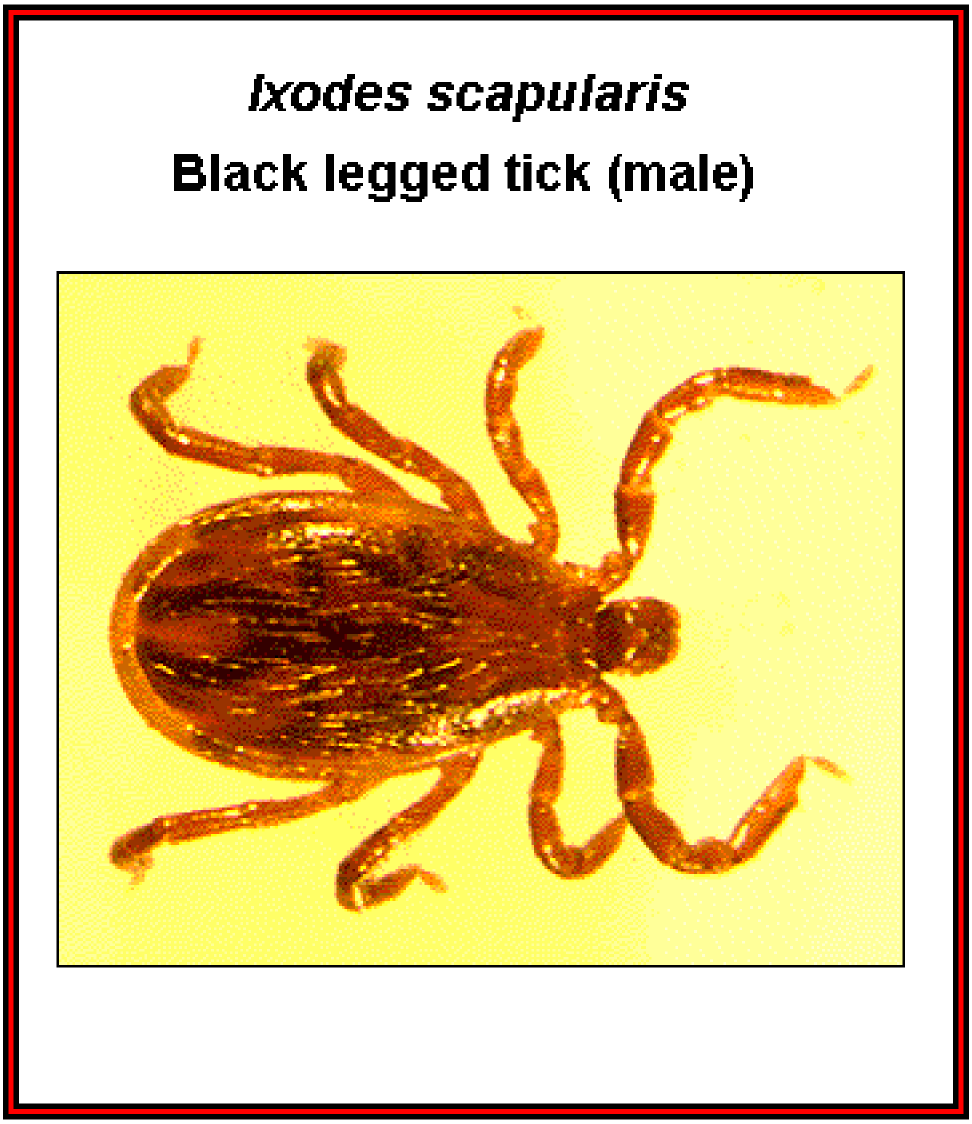
Various life cycle stages of *Ixodes scapularis*. Two nymphs are shown at the top of the image; bottom left = male; bottom right = female. (Scanned and modified from a transparency provided by Jim Occi.)



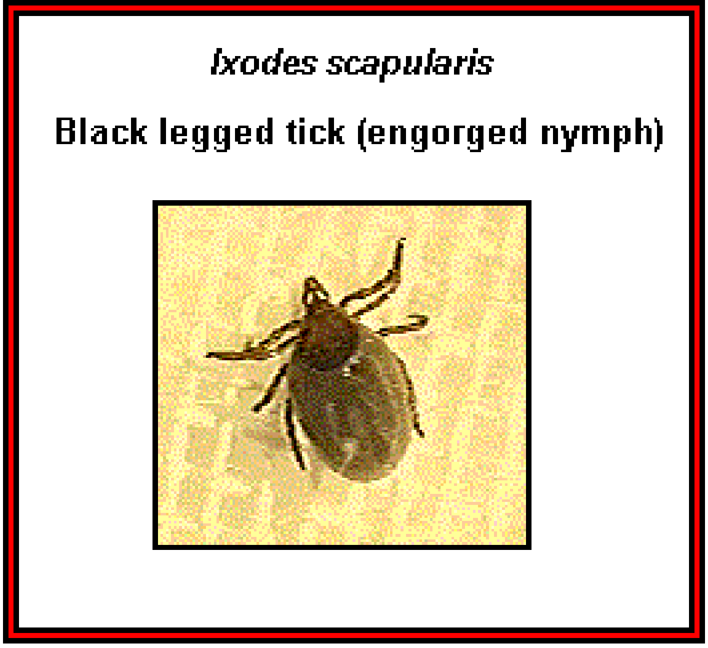
Various life cycle stages of *Ixodes scapularis* (from left to right, female, male, nymph). (Bottom scale in mm, and two sesame seeds are shown.) (Scanned and modified from a transparency provided by Jim Occi.)



Various life cycle stages of *Ixodes scapularis*. (From the left, larva, nymph, two engorged nymphs, female (top), and male (bottom)). (Bottom scale in mm.) (Scanned and modified from a transparency provided by Jim Occi.)



A male *Ixodes scapularis*. Original image obtained from and copyrighted by the Iowa State University Entomology Image Gallery, and used with permission.



Ixodes scapularis (engorged nymph). Original image obtained from and copyrighted by the Iowa State University Entomology Image Gallery, and used with permission.

Ixodes scapularis (larva). Original image obtained from and copyrighted by the Iowa State University Entomology Image Gallery, and used with permission.

Graphic Images of Parasites

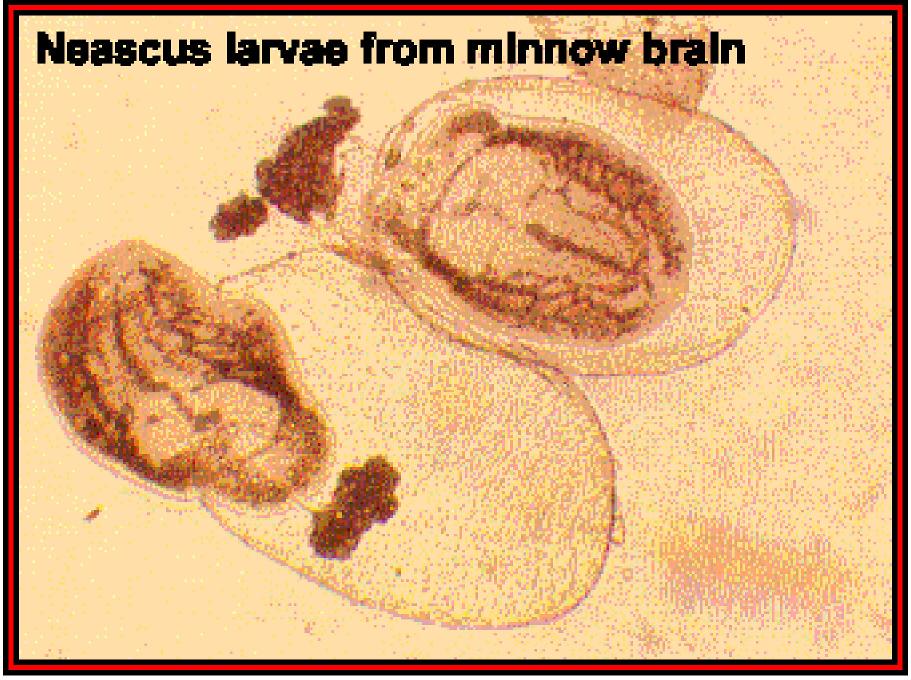
Uvulifer sp.
(black spot in fish)

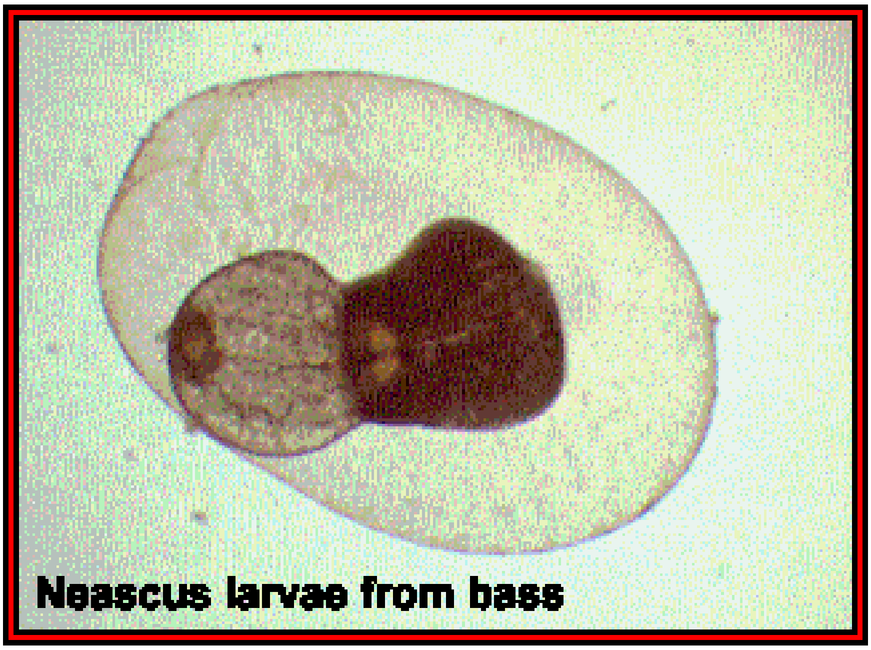
Several members of this genus cause "black spot" in fish --- the best known species is *Uvulifer amboplitis*. The life cycles of most members of this genus are similar. The definitive host is most often a bird, and the parasite's eggs are passed in the bird's feces. The first intermediate host is a snail, and the second intermediate host is a fish. The fish is infected when cercariae penetrate the skin. The cercariae lose their tails and transform into a stage called the "neascus larva" or "neascus metacercaria." The definitive host is infected when it eats an infected second intermediate host.

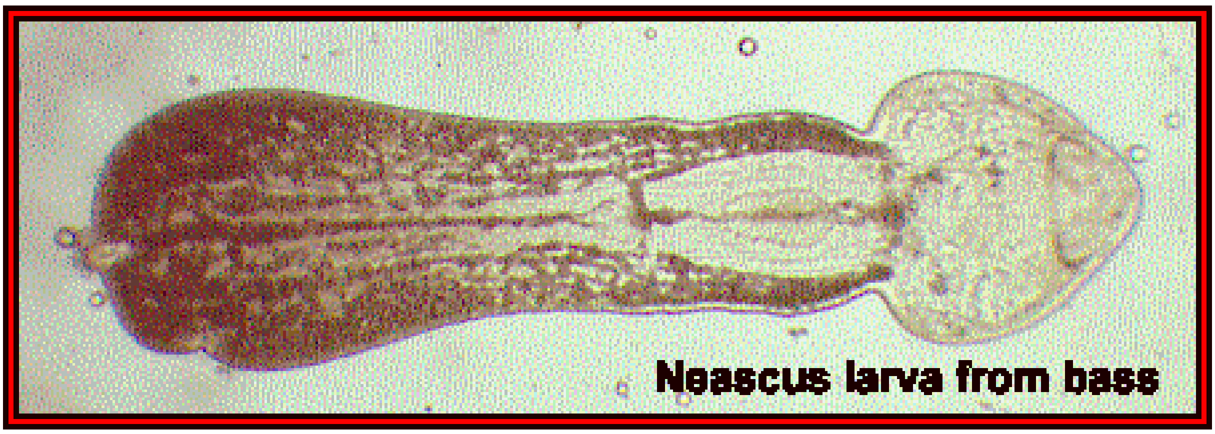
These encysted metacercariae often turn black and are visible on the fish's surface -- hence, "black spot" in fish. Heavily infected fish are often discarded by fishermen, although they pose no threat of infection to humans.

A fish infected with *Uvulifer* sp. metacercariae (neascus metacercariae).

The following three images are neascus metacercariae from various sources.


Neascus larvae from minnow brain

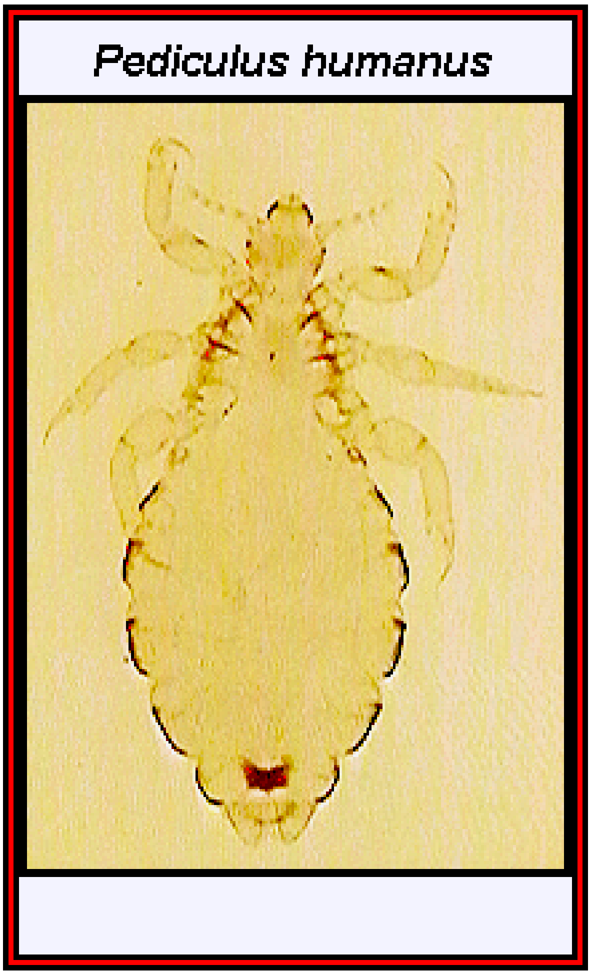

Neascus larvae from bass


Neascus larva from bass

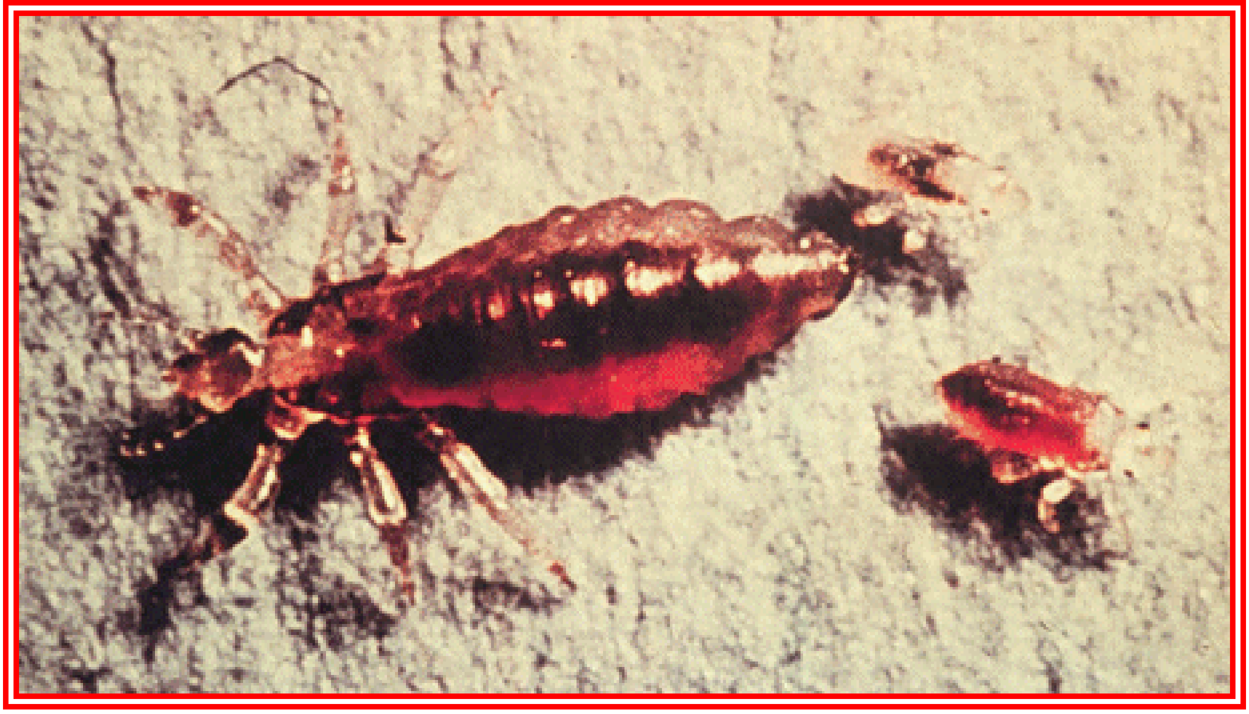
Pediculus humanus and *Phthirus pubis*
(body and pubic [crab] lice)

Lice are cosmopolitan parasites of humans, occurring in all areas of the world and in all socio-economic classes. The body louse will serve as the vector for typhus (caused by *Rickettsia prowazekii*), trench fever (caused by *Rochalimaea quintana*, a rickettsia), and relapsing fever (caused by a spirochete, *Borrelia recurrentis*). Severe epidemics of these diseases have occurred throughout history, particularly during wars, so lice and the diseases they spread have played an important role in human history.

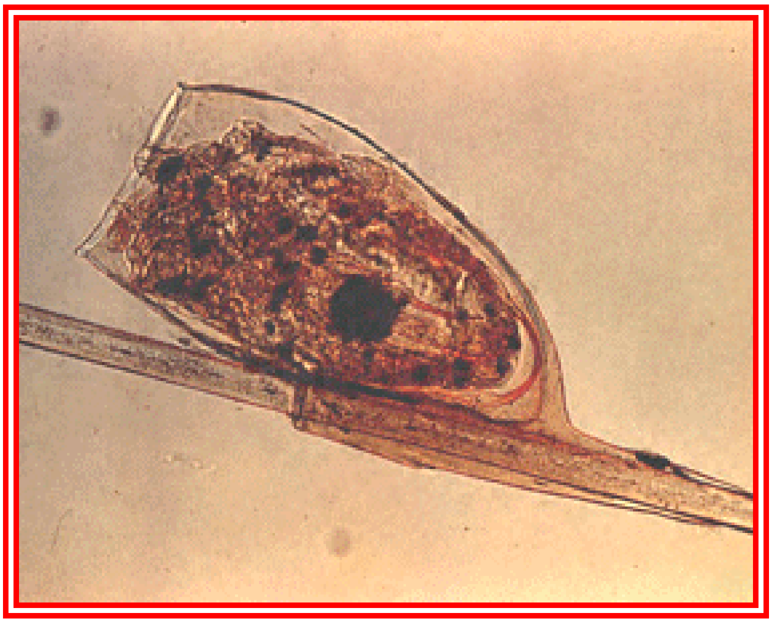
Lice are spread from human to human most often by direct contact or contact with contaminated clothing, etc. Body lice are restricted most often to the human body and head (some authorities believe the head louse is a separate species). Crab lice are most often restricted to the pubic region, but may spread to the armpits, facial hair (beard, etc.), eyebrows, and eyelashes. Infestations with lice are not a serious problem (as long as the lice are not infected with a disease), but they can cause a number of uncomfortable symptoms, including skin irritations and intense itching.



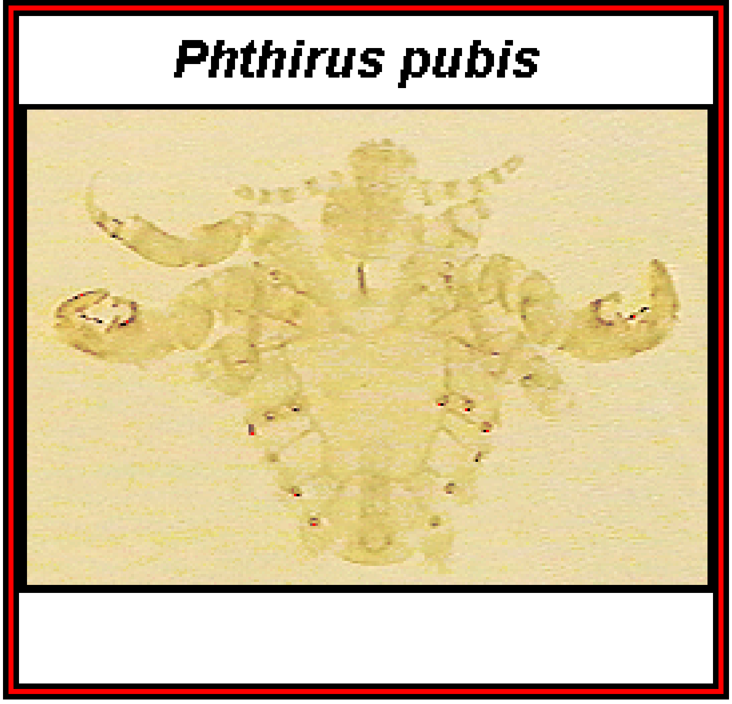
Pediculus humanus, the human body louse (approximate length = 2 mm). (Original image from the Entomology Image Gallery.



Pediculus humanus, the body or head louse. (Original image from Department of parasitology, Chiang Mai University, and used with permission.)



A "nit" or egg of *Pediculus humanus*. (Original image from Department of parasitology, Chiang Mai University, and used with permission.)



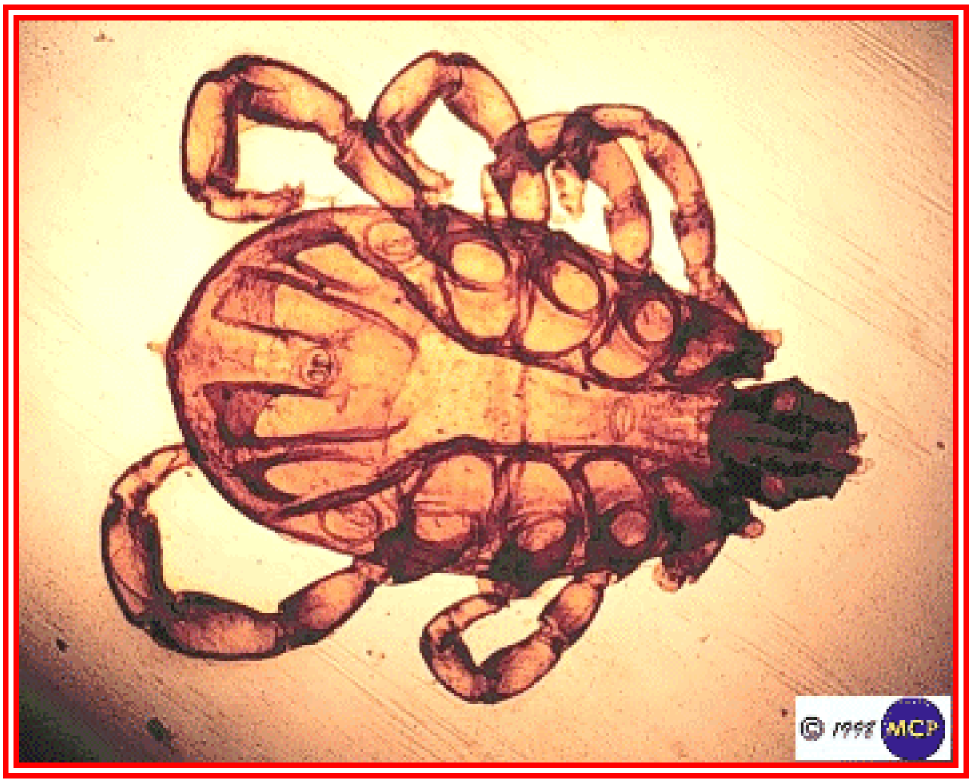
Phthirus pubis, the pubic or crab louse (approximate size = 1.5 mm). (Original image from the Entomology Image Gallery.

A crab louse attached to a hair. (Original image from "Featured Creatures" and copyrighted by the University of Florida).

Boophilus microplus
(southern cattle tick)

Boophilus microplus is a one-host tick distributed throughout much of the world. It is found in Mexico, much of Africa, Central and South America, Madagascar, Taiwan, and Australia. At one time it was found in the United States, but has been eradicated. It infects a variety of animals, including cattle, sheep, goats, and horses, but it seems to prefer cattle. In Australia, *B. microplus* is considered to be the most serious ectoparasite of cattle.

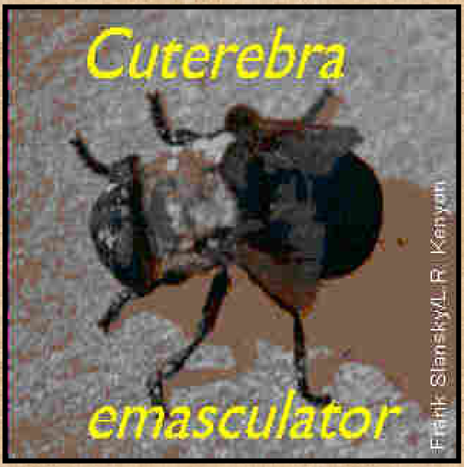
This tick transmits several diseases known collectively as 'tick fever.' These diseases include babesiosis (caused by the apicomplexans *Babesia bovis* and *B. bigemina*) and anaplasmosis (caused by the rickettsia *Anaplasma marginale*). Members of this genus have also been implicated as vectors for several viral hemorrhagic fevers (e.g., Crimean-Congo hemorrhagic fever).



Boophilus microplus, male. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Boophilus microplus, engorged female. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

The Tree Squirrel Bot Fly



Welcome to our tree squirrel bot fly home page! We are attempting here to provide accurate, up-to-date information about this insect (*Cuterebra emasculator* Fitch) and its relationship with the squirrels it parasitizes, based on published scientific studies, unpublished information provided to us by wildlife rehabilitators, veterinarians and others, and our own unpublished observations and data, resulting from the collaboration of an entomologist (a scientist who studies insects) and a wildlife rehabilitator (a biologist who cares for injured and orphaned animals) spanning almost 20 years of experience with tree squirrels and their bot fly parasites in northcentral Florida (About the authors).

Below we list links to a variety of topics pertaining to the tree squirrel bot fly and other flies that also parasitize mammals (including humans). Although several of the linked pages are not yet available, we feel that there is enough useful information to make it worthwhile to post this site in its present form. We hope to complete more of these pages in the near future, although some of these topics are longer-term projects.

If you observe squirrels in the summer with 'lumps' or 'tumors' and are concerned that this might be a disease that could spread to uninfested squirrels, pets or people, or if you are wondering if there is anything you can do to help the infested squirrels and to prevent other squirrels from getting infested, see overview of 'lumpy' squirrels. The taxonomy, distribution, life cycle & behavior [*link not yet available*] of the tree squirrel bot fly are described, with links to more in-depth descriptions of its life cycle stages: the adults & eggs [*link not yet available*], larvae [*link not yet available*] and pupae [*link not yet available*] as well as the warbles or lumps in the host animal's skin produced by the larvae (which are also called 'bots', hence the name 'bot flies'). Although bot fly infestation typically is not contagious, there is another 'lump-causing' affliction, squirrel fibromatosis (also called squirrel fibroma or squirrelpox), a viral disease that can be spread from infected to uninfected squirrels. Infestation of host animals [*link not yet available*] by these parasites is described, including the species, sex, age and location on the host's body and the effects of bot fly infestation on the host animal [*link not yet available*]. Related to the latter topic is the story of how this insect got its name (What's in a name: *Cuterebra emasculator*, the 'emasculating' bot fly) [*link not yet available*].

A substantial amount of information is available on the biology of the tree squirrel bot fly, but much remains to be learned (see Unanswered questions about the tree squirrel bot fly). When biological details for this species are lacking, if possible we provide information for different species of bot flies (those that attack other species of rodents [mice, rats, voles, pocket gophers, etc.] or lagomorphs [rabbits and hares]) in order to offer a general overview for the biology of these insects. However, we caution that as more information becomes available, each species of bot fly will undoubtedly be found to differ from the others in certain aspects of its life history, associated with differences in habitat, seasonal occurence, host species attacked, etc. As just one example of such differences, it is known that the peak flight activity of some bot fly species occurs in the late morning/early afternoon whereas the adults of a different species are most active during late afternoon/early evening (see adults

& eggs [*link not yet available*]).

References to published literature are linked to an annotated list of citations (Bot fly literature [*link not yet available*]). To assist persons with little or no entomological (= insect-associated) expertise, specialized terminology is defined in a bot fly-associated glossary[*link not yet available*].

For veterinarians and wildlife rehabilitators who may encounter injured or orphaned animals infested with bot fly larvae, information is provided on the non-surgical removal of larvae from squirrels [*link not yet available*]. Using forceps to extract bot fly larvae through the natural opening in the warble (the warble pore) without surgically cutting the warble and without anesthesizing the animal, reduces post-operative stress and the risks of both anesthesia and secondary infection.

Most species of bot flies usually attack wild animals but atypical infestations of domestic animals & pets [*link not yet available*] and humans [*link not yet available*] can occur. Also provided is a description of the one bot fly species that typically does infest people, the 'human bot fly', *Dermatobia hominis* [*link not yet available*]. This species does not occur in the United States; it is found in southern Mexico and several other Latin American countries. We also list links to other internet websites that address bot flies, related flies, other insects, other arthropods, wildlife and wildlife rehabilitation.

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Finally, to help in our goal of providing accurate and up-to-date information, we request that you contact us with corrections, additions and other comments and questions about the material presented here.

Links to information (and many pictures) about bot flies:

- Overview of 'lumpy' squirrels
  - What causes 'lumpy' squirrels?
  - Can this affliction spread from infested squirrels to uninfested squirrels, pets or people?
  - Is there anything one can do to help cure bot fly-infested squirrels, and to prevent other squirrels from getting infested?
- Taxonomy, distribution, life cycle and behavior {*Link not yet available*}
- Adults & eggs {*Link not yet available*}
- Larvae & pupae {*Link not yet available*}
- Warbles
- Squirrel fibromatosis
- Host infestation: species, sex, age & location on the body {*Link not yet available*}
- Effects of bot fly infestation on the host animal {*Link not yet available*}
- What's in a name: *Cuterebra emasculator*, the 'emasculating' bot fly {*Link not yet available*}
- Unanswered questions about the tree squirrel bot fly
- Glossary of bot fly-associated terms {*Link not yet available*}
- Published literature about bot flies & their relatives {*Link not yet available*}
- About the authors

Especially for veterinarians and wildlife rehabilitators:

- Non-surgical removal of larvae from squirrels {*Link not yet available*}

Bot fly encounters with domestic animals & humans:

- Atypical bot fly infestations of:
  - Domestic animals {*Link not yet available*}
  - Humans {*Link not yet available*}
- The 'human bot fly' {*Link not yet available*}

Other internet links:

- Bot flies that typically infest rabbits and rodents (i.e., *Cuterebra* species)
- Bot flies that infest other wild mammals, domestic animals and humans
- Insects & other arthropods
- Wildlife (especially North American small mammals) and wildlife rehabilitation

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Frank Slansky & Lou Rea Kenyon // fslansky@ufl.edu

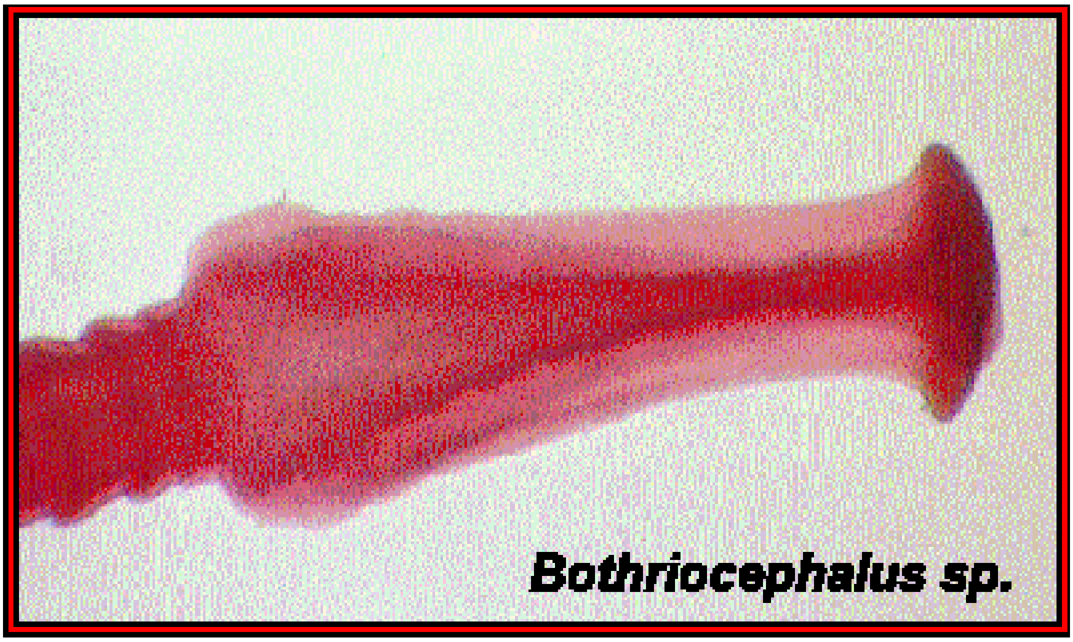
Version 1.2 (August 20, 2001)

Graphic Images of Parasites

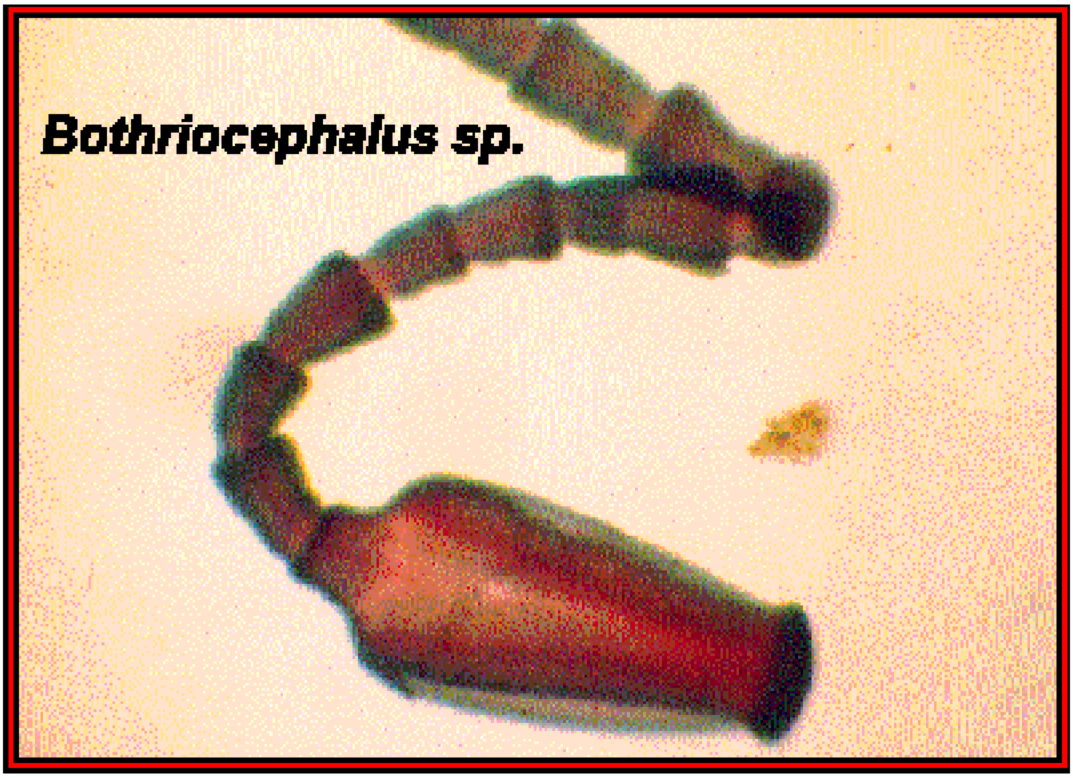
Bothriocephalus sp.

Members of this genus have a characteristic scolex that is characterized as "elongated, somewhat depressed, with a bilobed apical disk whose bothrial edges are indented, the two indentations being connected by a groove." The taxonomy and systematics of this genus is uncertain as "this genus was formerly a convenient receptacle for unassigned pseudophyllidean forms," and at one time contained more than 200 species.

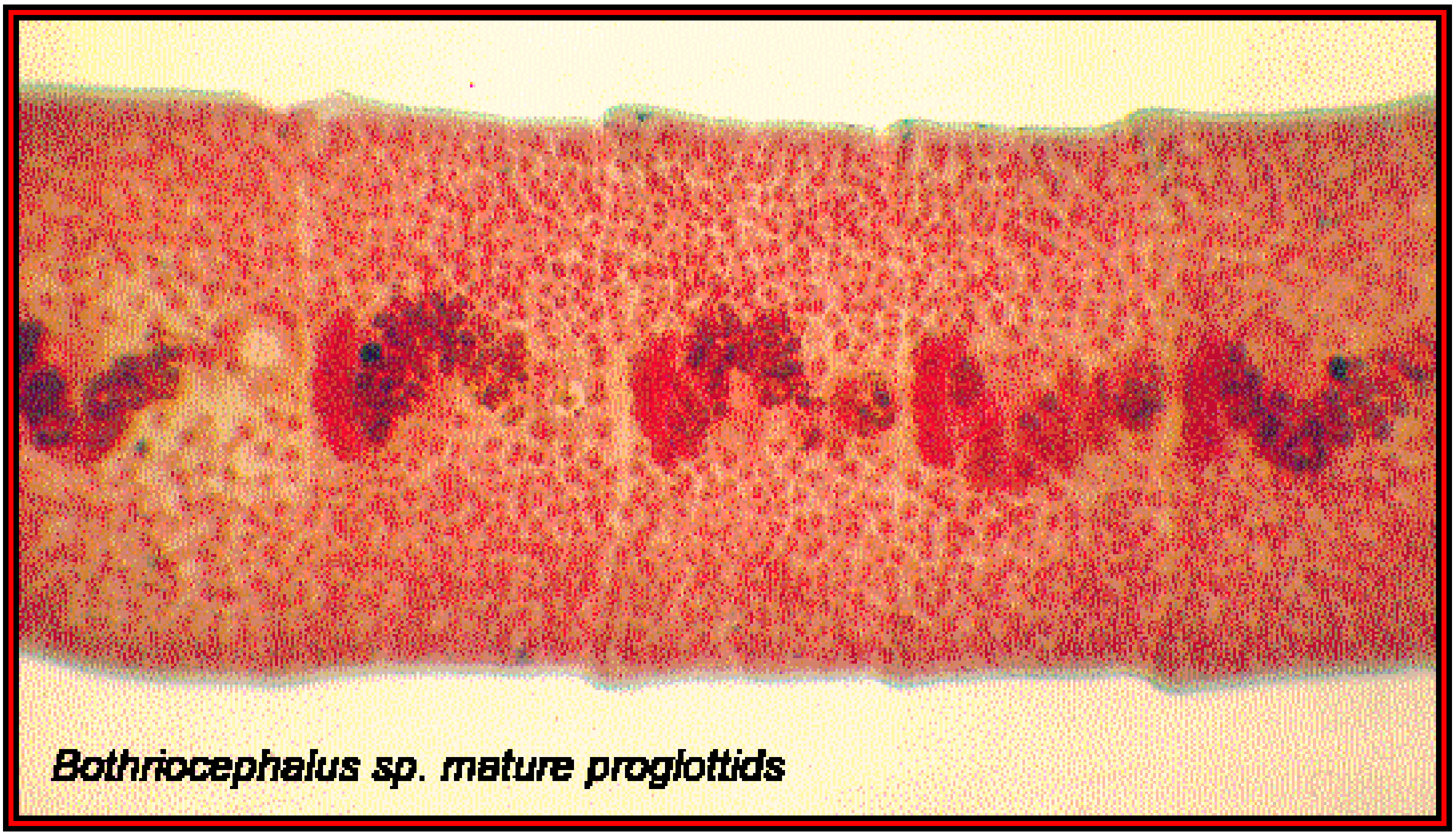
(Reference: Wardle, R.A., and McLeod, J.A. (1952) *The Zoology of Tapeworms*. University of Minnesota Press.)



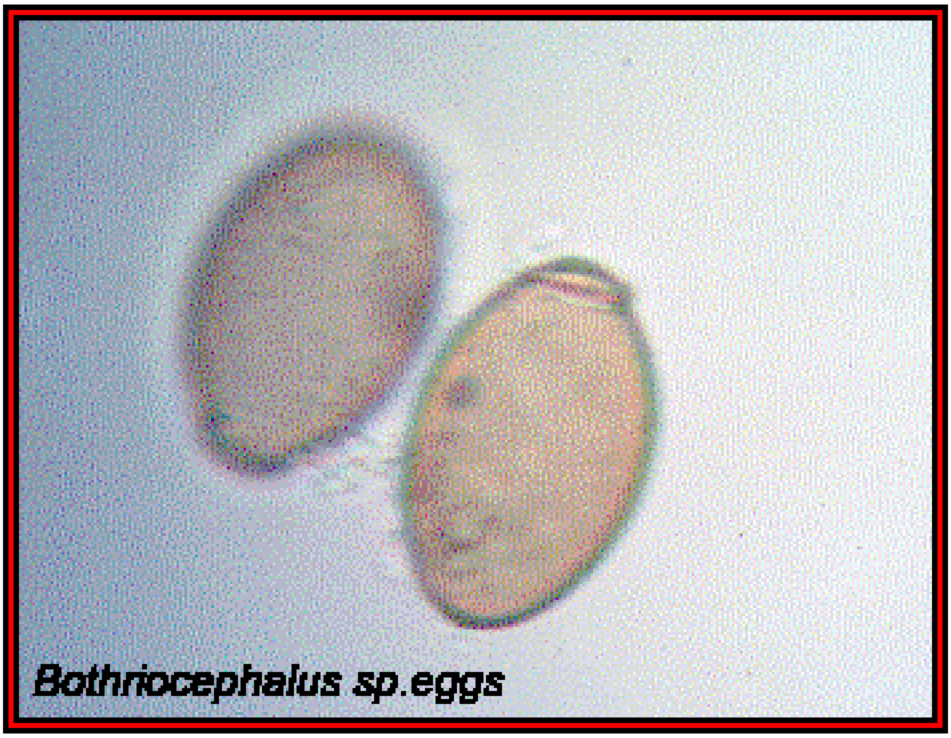
A stained whole mount of the scolex of *Bothriocephalus* sp. recovered from a walleye.



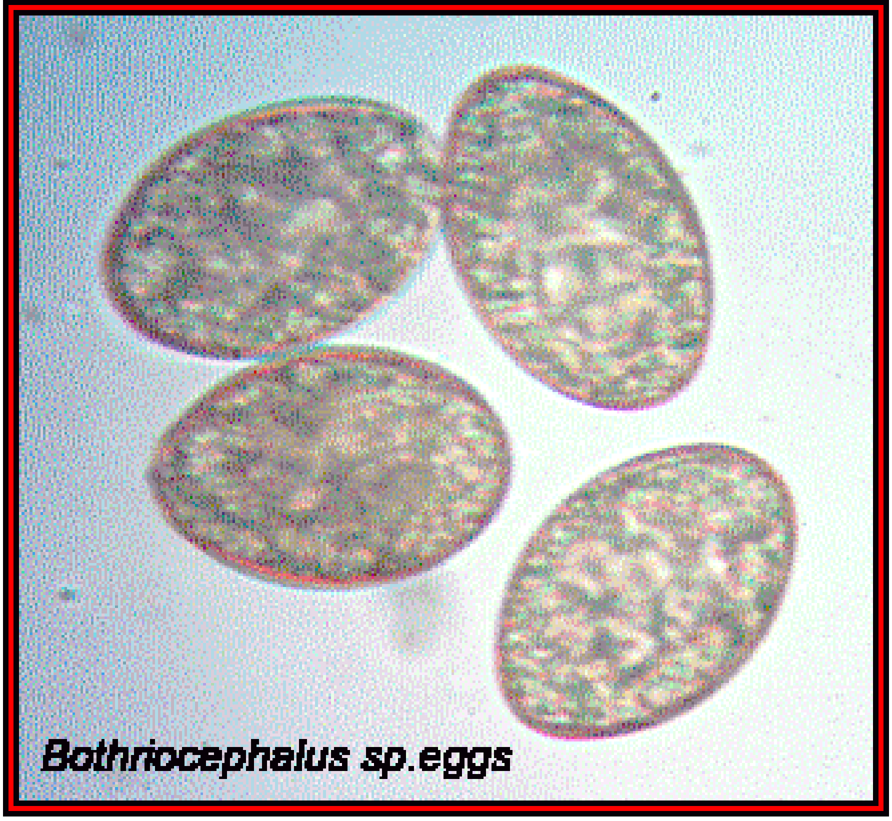
A stained whole mount of the scolex of *Bothriocephalus* sp.



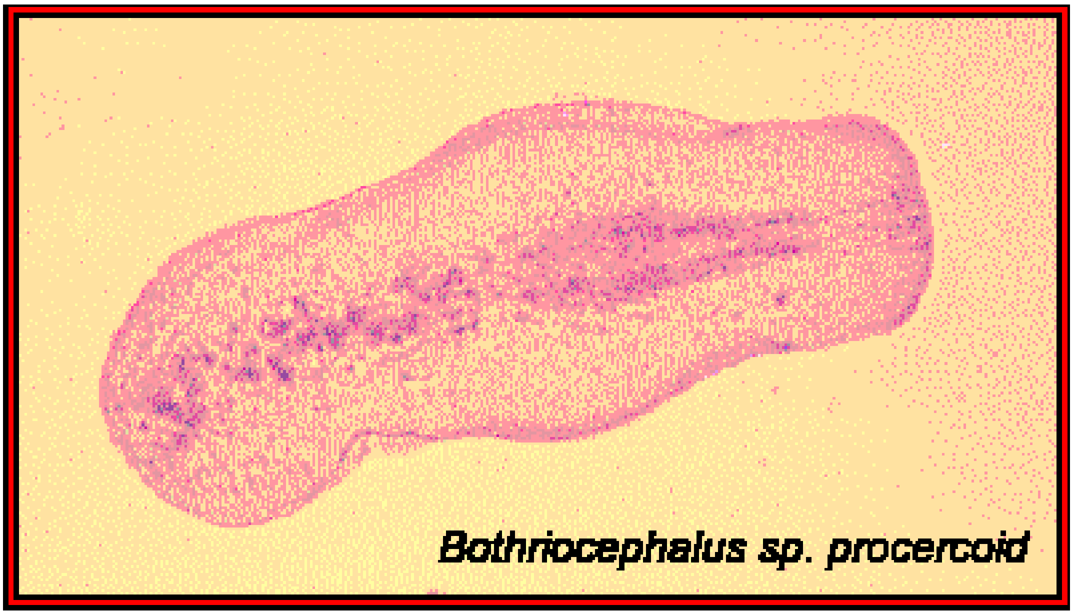
A stained whole mount of the proglottids of *Bothriocephalus* sp. recovered from a newt. The proglottids are typically "pseudophyllidean," with a posterior ovary (the dark red organ), a central uterus with eggs, and disperse testes and vitellaria.



Eggs of *Bothriocephalus* sp. from a walleye. Note the operculum on the right hand egg.



More examples of *Bothriocephalus* sp. eggs.



A procercoid of *Bothriocephalus* sp. recovered from a white bass.

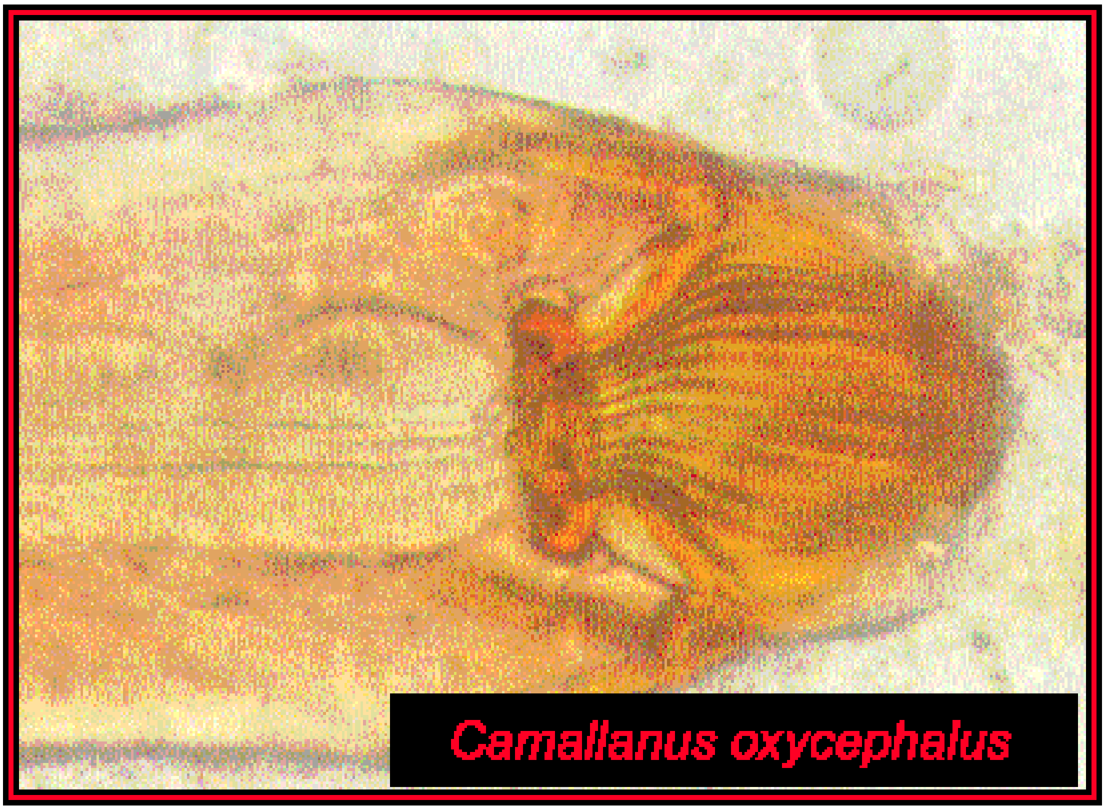
Brugia malayi
(brugian filariasis, elephantiasis)

Many aspects of the biology of *Brugia malayi* are similar to *Wuchereria bancrofti*. It is a vector borne disease, spread by mosquitos (view diagram of the life cycle), and it can cause elephatiasis. The primary difference between the two species is that brugian filariasis is not as widely distributed as is bancroftian filariais, although the distributions of the two diseases overlap in many areas of the world (view geographic distribution of filariasis).

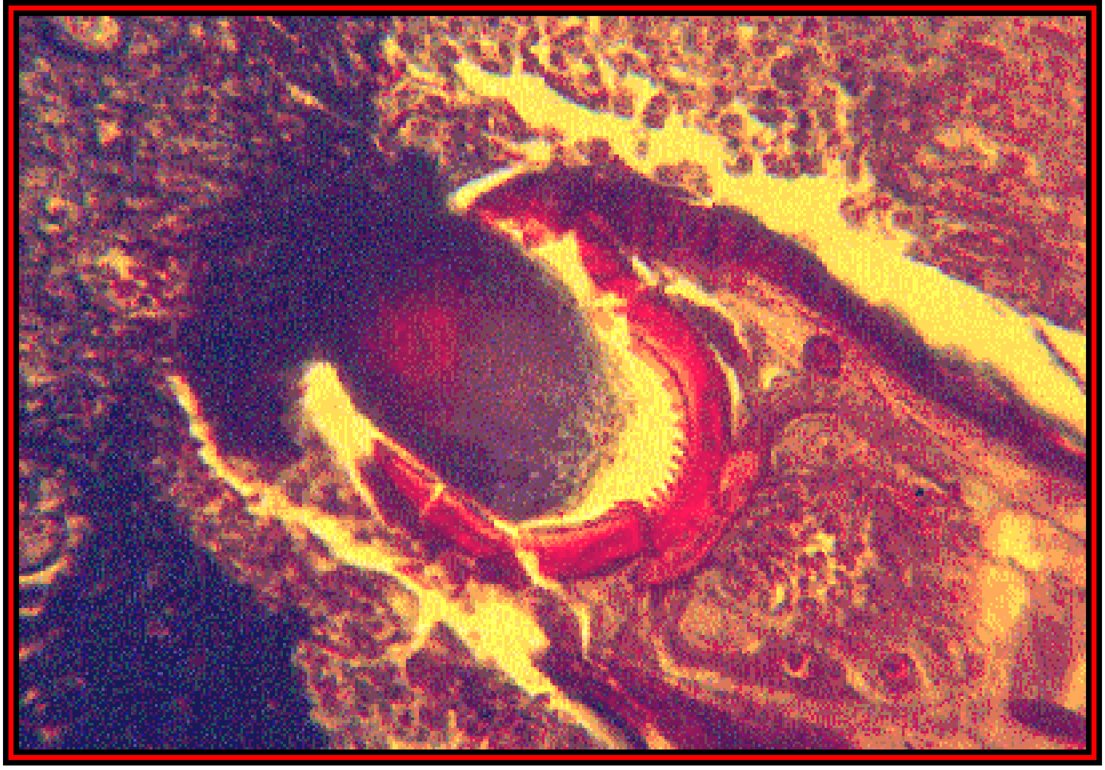
Camallanus sp.

Members of the genus *Camallanus* are parasites of cold-blooded vertebrates, primarily fish. The larvae of this genus are passed in the feces of the infected host, and a copepod serves as the intermediate host. Small fishes can serve as transport hosts.

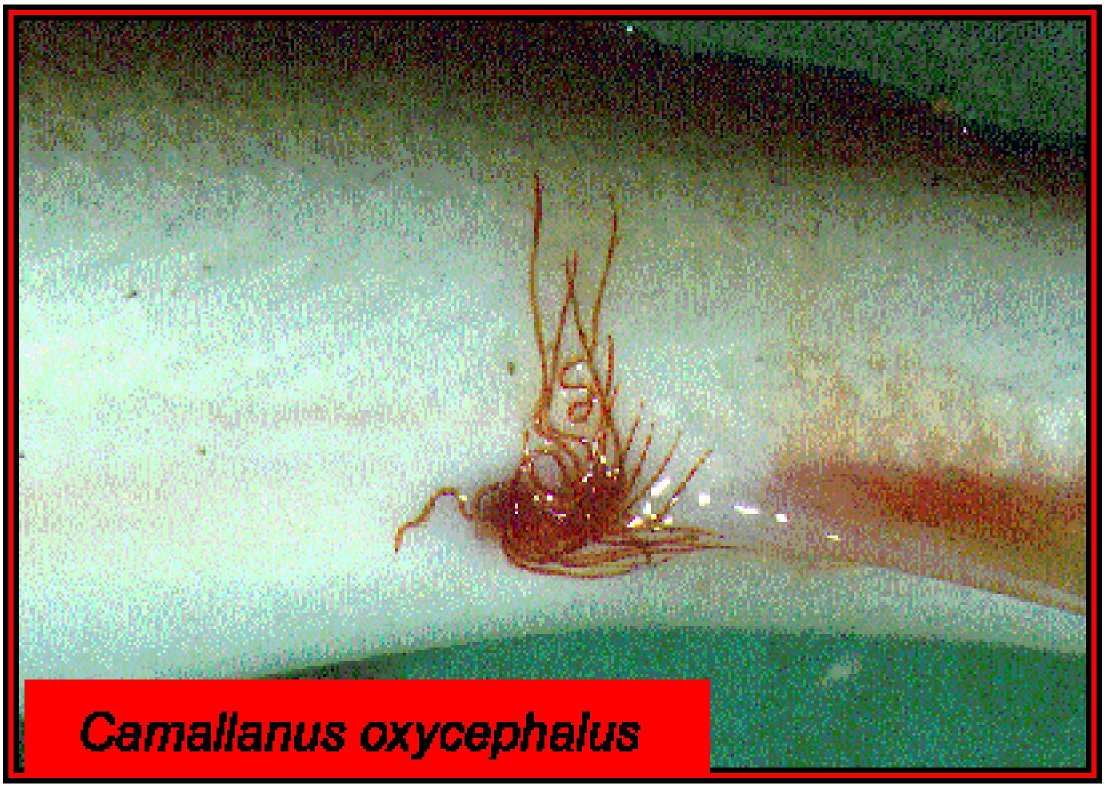
(Reference: Cheng, T.C. (1973) *General Parasitology*. Academic Press.)



The anterior end of a *Camallanus oxycephalus* recovered from a bowfin. Note the oral cavity contains well developed buccal plates.



A histological section of *Camallanus oxcephalus* in a white bass. The well developed buccal plate is stained dark red in this section, and the destructive action of this plate on the host's intestinal epithelium is clear.



Camallanus oxcephalus exiting the anus of a white bass.

Graphic Images of Parasites

Capillaria hepatica

This parasite is found primarily in rodents, although it has been reported in canines and humans. As the parasite's name implies, the worms live in the host's liver, generally surrounded by a connective tissue capsule.

The adult female produces eggs, but few of these eggs are passed in the host's feces. Rather, most of the eggs are deposited in the liver parenchyma, only to be released when the infected host is eaten by a predator. The eggs are then liberated from the liver tissue and passed in the predator's feces. Once returned to the soil, the eggs are ingested by the next host and hatch in the small intestine. The larvae (juveniles) penetrate into the tissues of the small intestine, enter the portal circulation, and are transported to the liver. Once in the liver the juveniles grow into sexually mature adults.

As noted above, this parasite has been reported from humans. In humans, this parasite has also been implicated as a cause of visceral larval migrans (VLM).

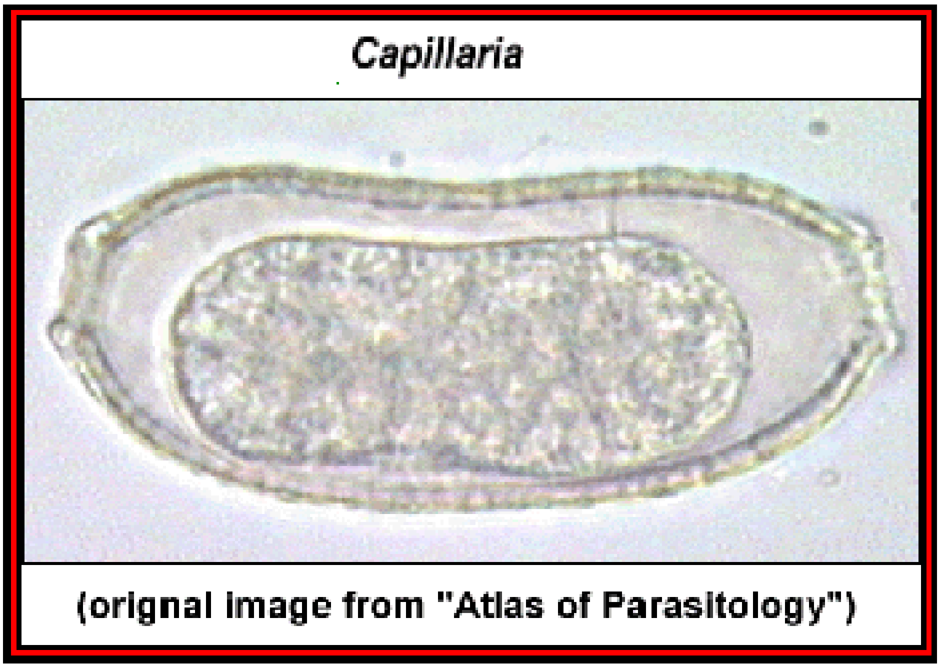
Histological section of *Capillaria hepatica* eggs in the liver of a mouse.

A higher magnification of the above image.

Capillaria philippinensis

Capillaria philippinensis is a parasite of the human small intestine. The male and female worms measure about 4 mm in length, and the females produce eggs and juveniles (larvae) that are passed in the human's feces. The eggs embryonate when they reach water, and they are eaten by fish. The eggs hatch in the fish, and the juveniles mature into infective forms in a few weeks. The definitive host is infected when it eats the fish containing infective juveniles (view a diagram of the life cycle). As in the case with *Strongyloides stercoralis*, the juveniles that are passed by females can reinfect the host directly (autoinfection), so massive infections with this parasite are possible. Heavy infections with this parasitic species cause serious damage to the lining of the small intestine resulting in symptoms such as diarrhea, abdominal cramps, malaise, etc. Fatal infections have been reported.

This parasite was originally discovered in humans in the Philippines, but has since been reported from humans in Thailand, Iran, Japan, and Egypt. Most authorities believe that this is a zoonotic infection, but the primary animal host remains unknown.

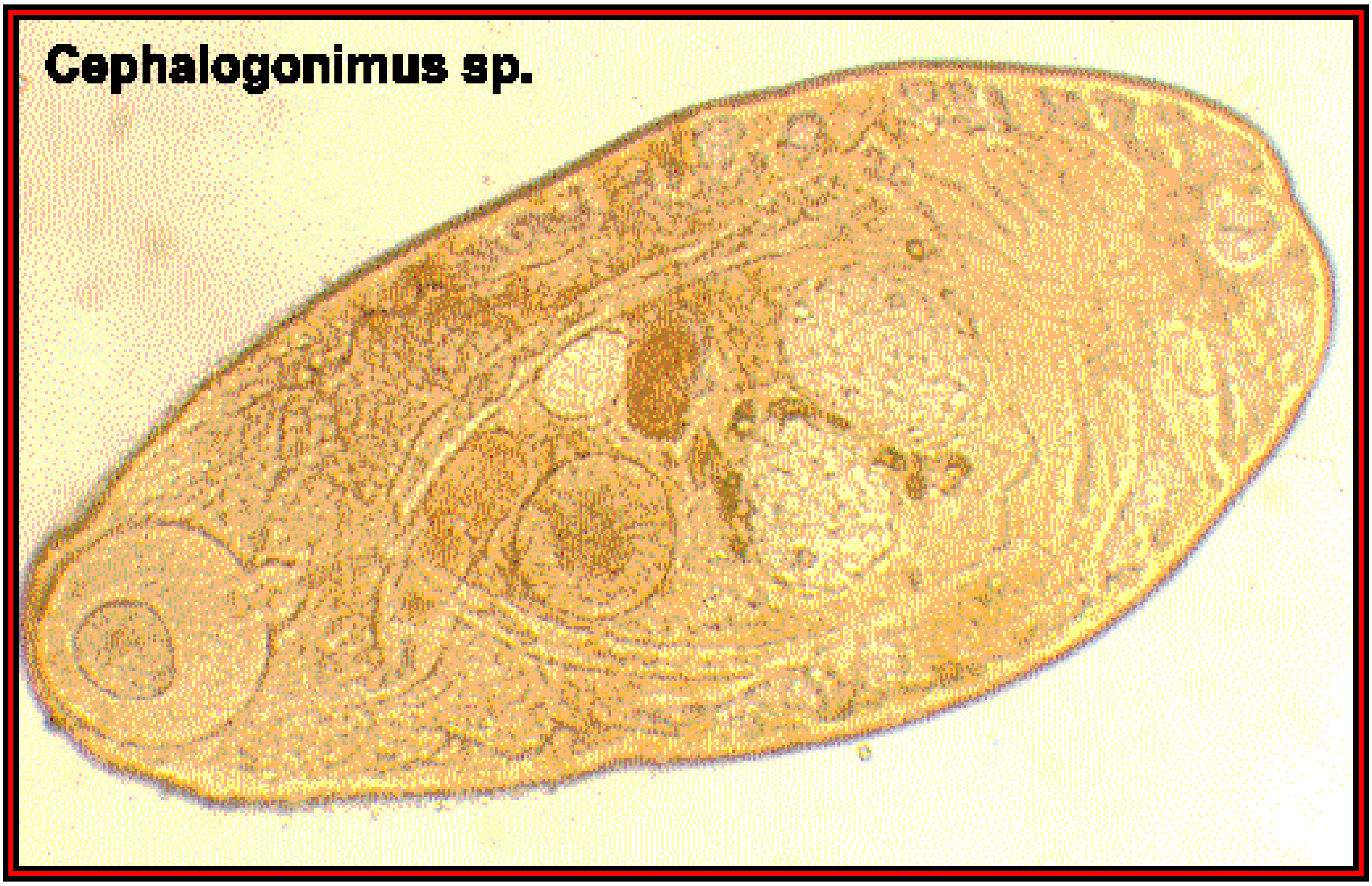


A *Capillaria* egg. Note the distinctive appearance. The eggs measure 50-60 µm in length.

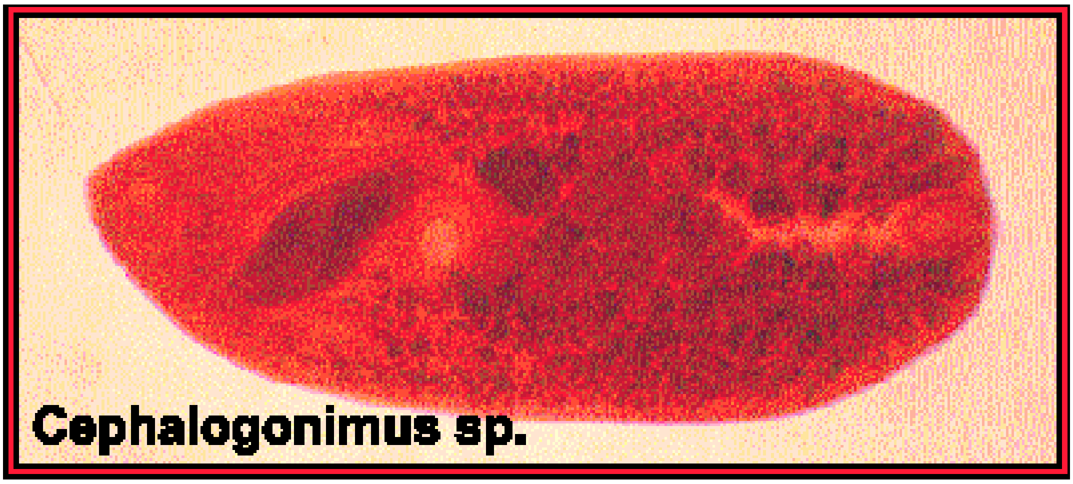
Graphic Images of Parasites

Cephalogonimus sp.

The life cycle of *Cephalogonimus americanus* utilizes frogs as the definitive host, and snails (*Helisoma antrosa* or *H. trivolvis*) as the first intermediate host. Cercariae liberated from infected snails encyst in the tissues of tadpoles, and frogs are infected when they eat infected tadpoles.



An unstained (living) specimen of *Cephalogonimus* sp. (probably *C. americanus*). Many of the internal organs are visible even without staining.



The above two images are specimens of *Cephalogonimus* sp. (probably *C. americanus*) recovered from *Rana pipiens*.

Swimmer's itch
(schistosome cercarial dermatitis)

In the 'schistosomes' (*Schistosoma* and related genera), the definitive host is infected when free-swimming cercariae penetrate the host's skin. If the schistosome is a species that normally infects humans, a cercaria penetrates the skin rapidly and transforms into a schistosomule, and the schistosomule enters the circulatory system and leaves the skin. Penetration of the skin by cercariae of human schistosomes may result no symptoms or in a mild inflammation of the skin (dermatitis), especially in hosts that have been exposed previously to cercariae.

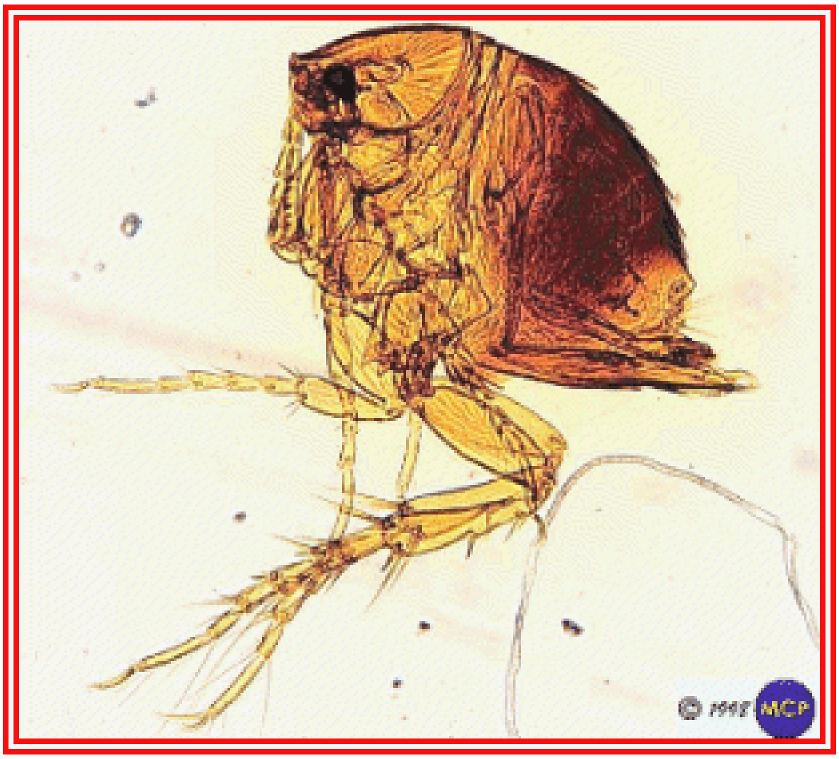
Schistosome cercariae are unable to differentiate the skin of different animals. If cercariae of non-human schistosomes come in contact with human skin, they will penetrate it just as if it was the skin of their normal host. When this occurs the schistosomules can cause a dramatic inflammatory response, especially in hosts that have been exposed previously, because (1) humans are an abnormal host and (2) the schistosomules remain in the skin for an extended period of time and eventually die there. The inflammatory response that results when non-human schistosome cercariae penetrate the skin of humans is called 'swimmer's itch' or schistosome cercarial dermatitis.

The cercariae of bovine and avian 'schistosomes' are probably responsible for a majority of cases of swimmer's itch, and infections have been reported throughout the world. Assuming that one swims, bathes, plays, etc., in a natural body of water in which these cercariae are found, there is virtually no way to prevent an infection. The risk of infection can be lowered by spending less time in the water or by drying off completely after getting out of the water. (Some people mention that covering your body with petroleum jelly will also decrease the risk of infection, but most people would find this less than appealing.) Schistosome cercarial dermatitis can be extremely uncomfortable and annoying, to the point of ruining your vacation, but the schistosomules will not develop into adult worms, and the infection is not life threatening.

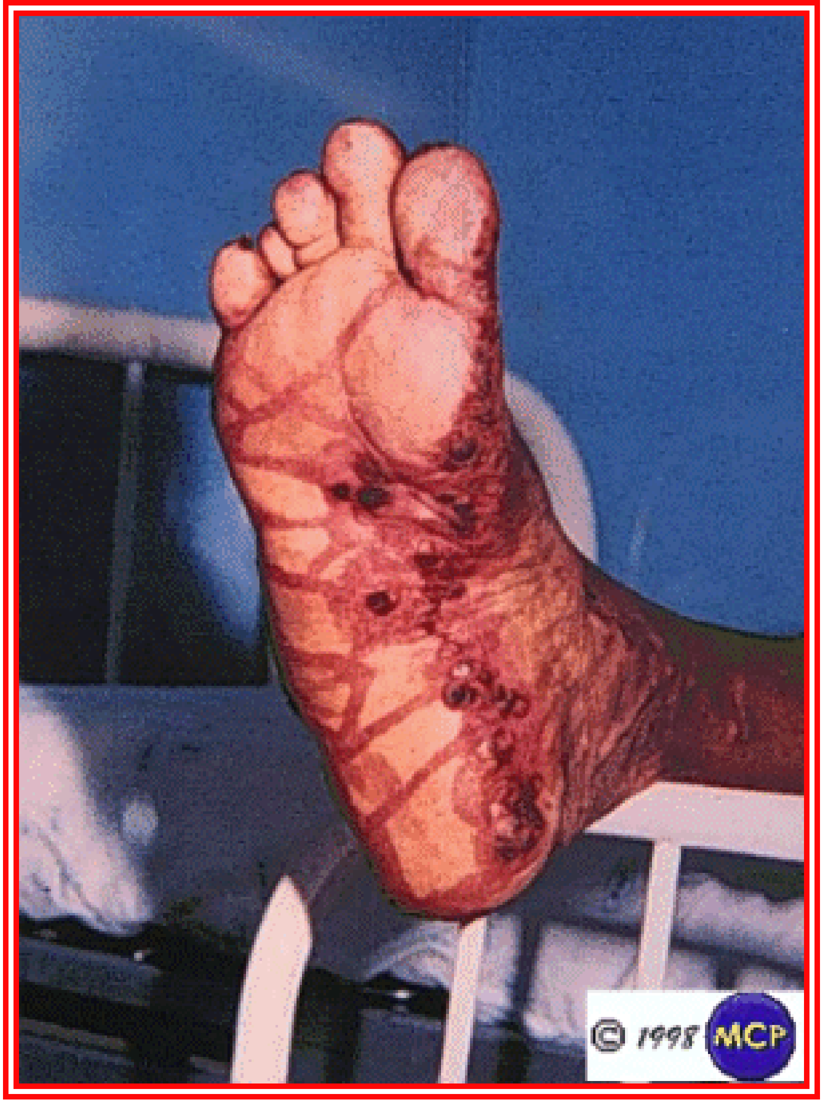
Tunga penetrans

(chigger, jigger, chigoe, chique, sand flea)

Tunga penetrans, also called the chigoe, jigger, chigger, chique, or sand flea, is a small flea (an insect) that infects humans and pigs. It is found in Central and tropical South America, as well as tropical Africa and India. This species should not be confused with "chiggers" or "chigger mites" (arachnids) which are distributed throughout most temperate and tropical areas of the world. Most species of fleas are ectoparasites and spend a lot of time on their hosts, but, as many people who own dogs or cats will testify, fleas can transfer from one host to another fairly easily. *T. penetrans* is different from most fleas in that the adult female burrows into the skin of the host and becomes a permanent resident of the cutaneous or subcutaneous tissues. The presence of the female flea can cause extreme itching, pain, and inflammation, and secondary infections may occur. Surgical removal of the fleas is the recommended treatment.



Tunga penetrans. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo and used with permission.



Tunga pentrans infecting the foot. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo and used with permission.

Graphic Images of Parasites

Chilomastix mesnili
(a commensal)

Most humans infected with *Chilomastix mesnili* suffer no symptoms, and many authorities regard this species as a commensal (i.e., on-pathogenic). Nevertheless, it is important to be able to differentiate *C. mesnili* from other flagellates that might be found in a human fecal sample for the same reasons that it is important to differentiate the commensal *Entameoba coli* from the pathogen *Entamoeba histolytica* (i.e., it can occur with more pathogenic forms and its presence indicates ingestion of food or water contaminated with human fecal material).

Trophozoite of *Chilomastix mesnili*. The single nucleus is evident, as is the characteristic "tear-drop" shape. Another characteristic of this species is the cytostome ("cell mouth"), but this can not be seen in this plane of focus; approximate size = 20 µm.

A cyst *Chilomastix mesnili*. The single nucleus is evident, as is the characteristic "lemon-drop " shape. The dark line next to the nucleus is one edge of the cytostome; approximate size = 12 µm.

A cyst of *Chilomastix mesnili*. This specimen demonstrates nicely the characteristic shape of the cyst.

Choanotaenia sp.

The life cycles of only one or two species of this genus are known. The definitive host is a bird, while the intermediate host is an insect. The metacestode stage is a cysticercoid.

Scolex of *Choanotaenia maculosa*. It is a typical cyclophyllidean scolex, having four well developed suckers and an armed rostellum.

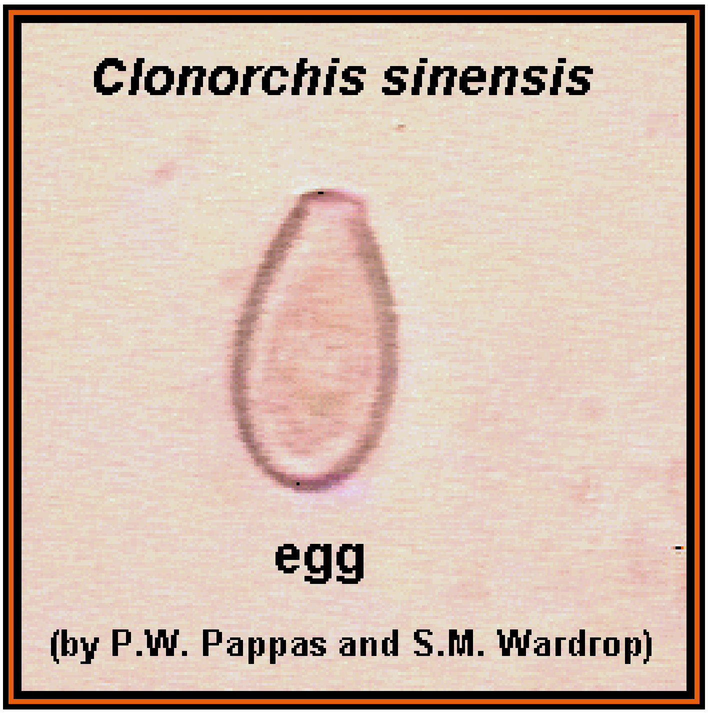
Graphic Images of Parasites

Clonorchis sinensis
(Chinese or oriental liver fluke)

Clonorchis sinensis is known as the oriental or Chinese liver fluke because it is distributed throughout Japan, Korea, China, Taiwan, and Vietnam (view geographic distribution). It is estimated that this species infects more than 30,000,000 humans in these areas. The parasite also infects a number of other animals, including dogs, cats, pigs, and rodents, and these animals serve as reservoirs of infection.

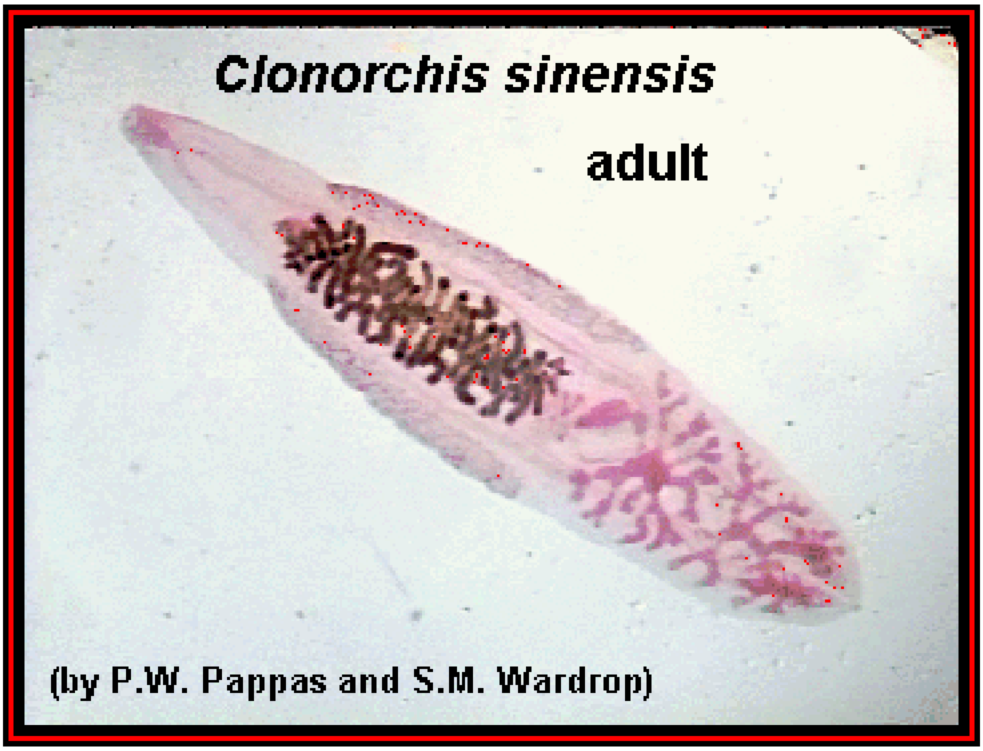
The adult worms measure between 10 and 25 mm in length. The do not actually live in the host's liver, but are found in the bile ducts inside of the liver. Eggs are passed in the host's feces and the first intermediate host is a snail. Cercariae emerge from the first intermediate host and infect the second intermediate host. The second intermediate host is a fish, and over 100 species of fish are susceptible to infection. The definitive host is infected when it eats raw or undercooked fish (view diagram of the life cycle). The metacercariae excyst in the host's small intestine, and the juvenile worm migrates up the common bile duct into the bile ducts inside of the liver. The worms can live at least 10 years, and possibly as long as 20 years.

The parasite causes thickening of the lining of the bile duct and an inflammatory response in the surrounding liver tissue. In heavy infections the bile duct epithelium can also be eroded, and the parasite's eggs will enter the liver tissue; in such cases the eggs are surrounded by a fibrotic capsule (granuloma). Heavy infections can also result in stenosis (narrowing or blockage) of the bile ducts. Since the parasites can live for years and the number of parasites tends to increase as a person ages, the damage to the liver and bile duct tends to accumulate over time and can result in death. As with many trematodes, diagnosis of the infection depends on recovering and identifying the parasite's eggs in a stool sample.

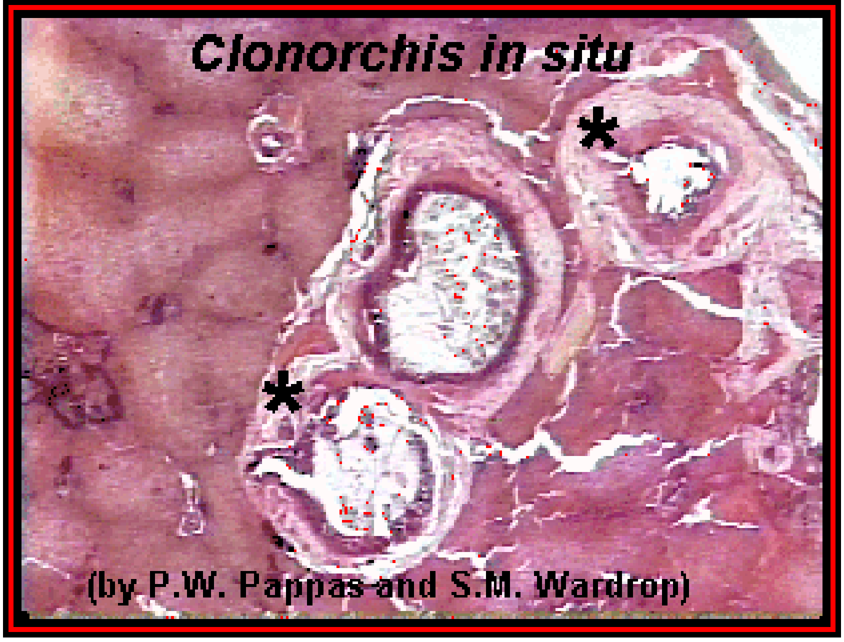


Clonorchis sinensis egg. The egg has a distinctive shape, sometimes described as "shouldered" or "light-bulb shaped;" approximate size = 25 µm in length

Another example of a *Clonorchis* egg. The operculum and abopercular "bump" are easily seen in this specimen.



Clonorchis sinensis, adult, stained whole mount; approximate size = 15 mm. Click here to view a labeled image of this parasite, or here to view a labeled line drawing of this parasite.



Section of *Clonorchis sinensis* in the bile duct. Note the thickening of the bile duct walls (*).

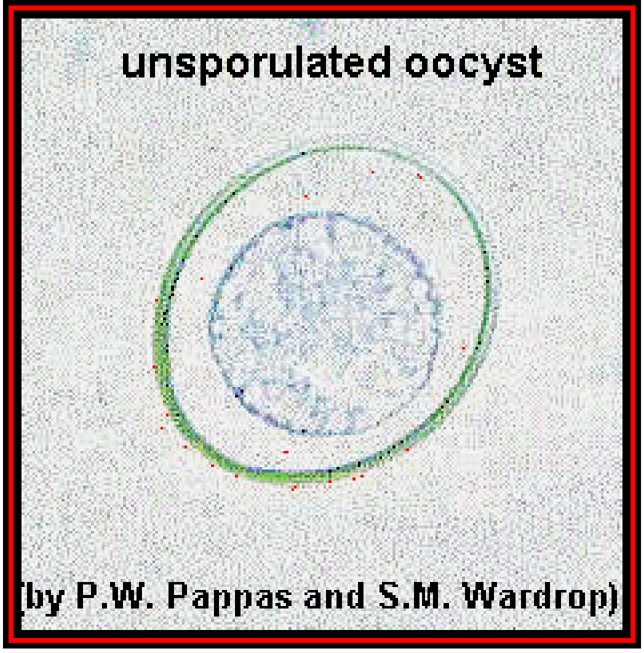
Eimeria and *Isospora*
(coccidiosis)

Members of these two genera are often referred to as the "coccidia." The two genera contain a large number of species that infect a variety of animals throughout the world. The diseases caused by these parasites are referred to collectively as coccidiosis, and they vary tremendously in virulence. Some species cause diseases that result in mild symptoms that might go unnoticed (i.e., mild diarrhea) and eventually disappear, while other species cause highly virulent infections that are rapidly fatal.

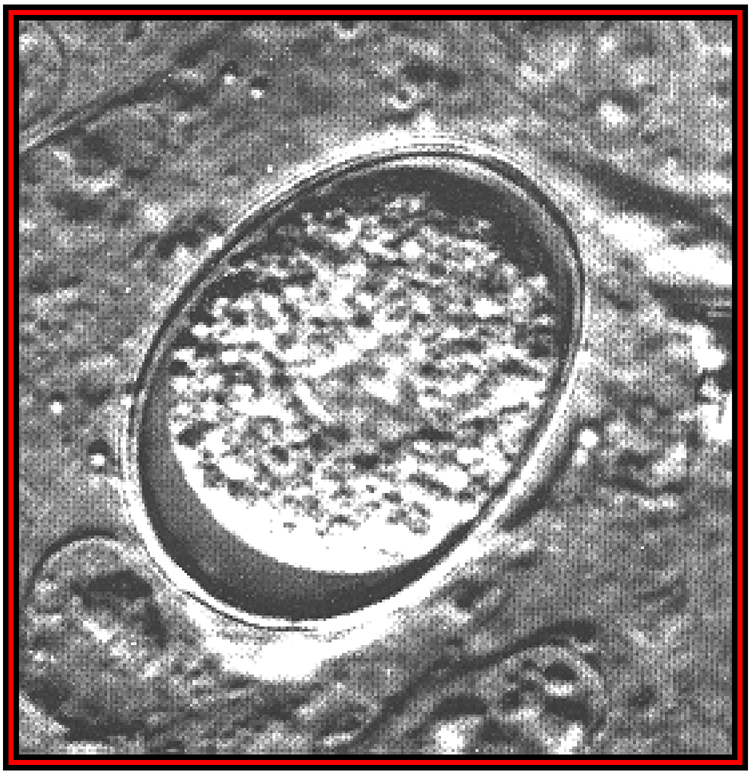
The life cycles of both genera are similar. A host is infected when it ingests oocysts that have been passed in the feces of another host. The oocyst excysts in the host's small intestine, and the sporozoites contained within the oocyst are liberated. The sporozoites penetrate the cells of the host's small intestine and reproduce asexually. Each generation of asexual reproduction produces multiple merozoites; the merozoites are liberated from the cell and infect new cells. It is this stage of the infection that can result in destruction of massive numbers of cells in the host's small intestine and, ultimately, lead to the host's death. Some of the merozoites that enter the host's cells transform into gametocytes. The gametocytes transform into gametes, the gametes fuse, and the resulting zygote begins to develop into an oocyst. The developing oocyst escapes from the host's cell, and it is passed in the host's feces. Typically, when the oocyst is passed in the feces, it is not infective because it does not contain sporozoites; this is an unsporulated oocyst. After several days (or weeks, depending on the species) outside of the host's body, the oocyst completes development and sporozoites are found within; this is a sporulated oocyst, and it is infective to the next host (view diagram of the life cycle).

Diagnosis of the infection is based on finding oocysts in the host's feces. Differentiation of the two genera and the species within the genera is based on the internal morphology of the oocyst. Thus, while it is possible to identify an unsporulated oocyst as a coccidian oocyst, it is virtually impossible to identify the parasite that produced the oocyst until the oocyst is sporulated.

Asexual multiplication of the parasite in the cells of the host's small intestine is self limiting (although in some species the parasite actually kills the host before asexual reproduction stops). That is, after several generations of asexual multiplication, the parasite simply stops dividing, the host stops passing oocysts, and the host is effectively cured of the infection.

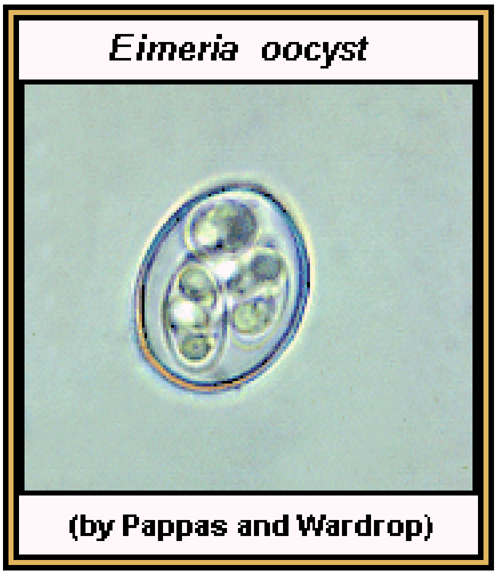


An unsporulated coccidian oocyst. Such oocysts typically measure between 35 and 50 µm. (Original image from the Oklahoma State University, College of Veterinary Medicine.)

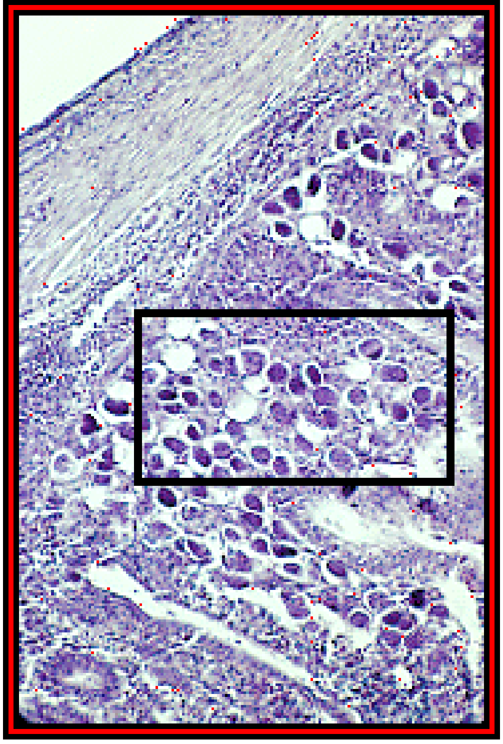


Another example of an unsporulated oocyst. (Original image from Gardiner *et al.*, 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Handbook No. 651).

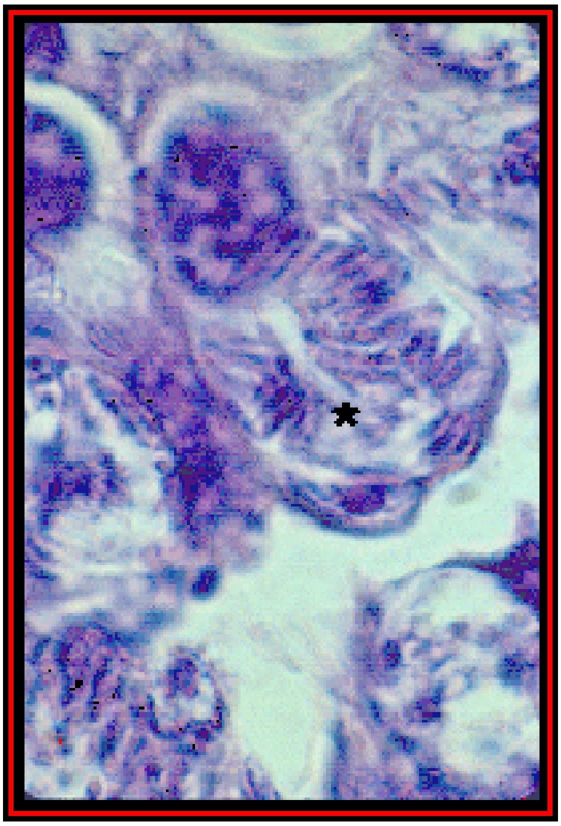
A sporulated coccidian oocyst. The oocyst contains two sporocysts, and this is typical of the genus *Isospora* (and *Toxoplasma*, although *Toxoplasma* oocysts are much smaller). Sporulated oocysts of the genus *Eimeria* contain 4 sporocysts . (Original image from the Oklahoma State University, College of Veterinary Medicine.)



A sporulated oocyst of *Eimeria* sp. This oocyst contains four sporocysts (only three can be seen).



A histological section showing the asexual reproductive stages of a coccidian in the tissues of the host's small intestine. Note the many developing meronts (=schizonts) (the large dark blue structures enclosed within the rectangle) in the tissues. Each meront will produce many merozoites.



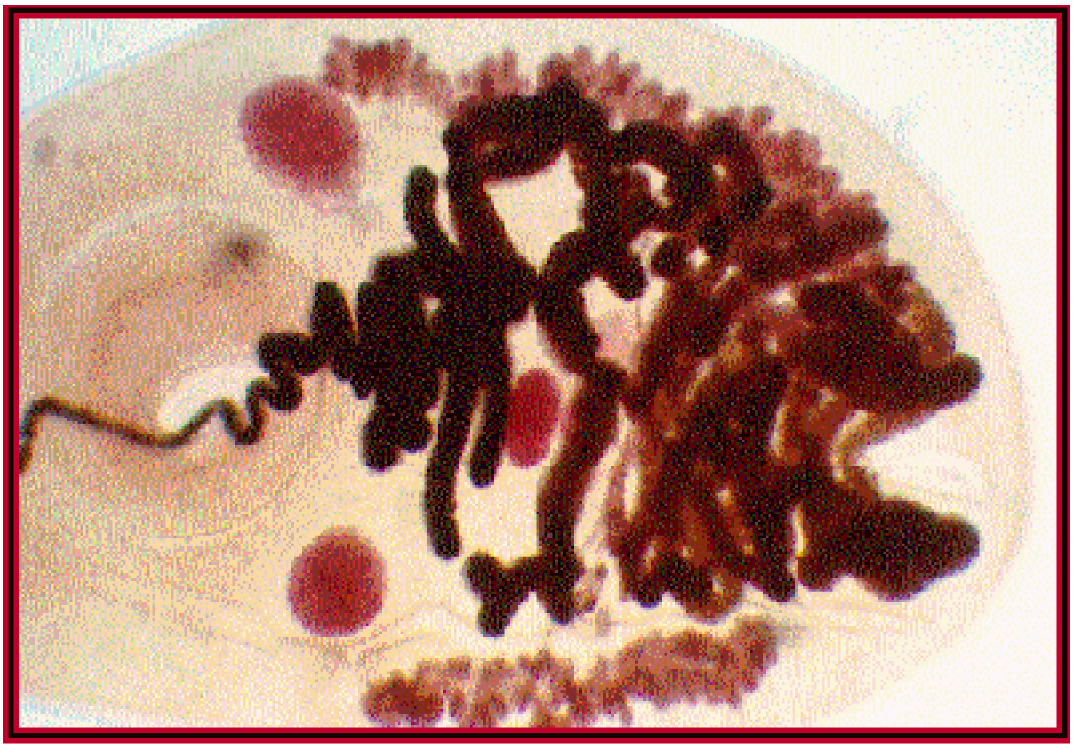
A higher power magnification of a developing meront. The individual developing merozoites (*) can be seen.

Graphic Images of Parasites

Conspicuum icteridorum

This parasite is found in the gall bladders of several species of birds, including grackles, blackbirds and meadowlarks. The first intermediate host is a land snail or slug, and the second intermediate host is a terrestial isopod. Definitive hosts are infected when they eat infected isopods.

The following two images show the anterior and posterior aspects of a stained whole mount of *Conspicuum icteridorum*. Note that the testes are anterior to the ovary, a characteristic of the family Dicrocoeliidae.



Graphic Images of Parasites

The "trichostongyles"

(*Cooperia, Haemonchus, Ostertagia, Nematodirus, Trichostrongylus*)

The "trichostrongyles" include several genera of economically important nematode parasites of domesticated livestock. The life cycles of most trichostrongyles are similar. The adult male and female worms live in the host's abomasum or small intestine, and eggs are passed in the feces. The eggs hatch and infective juveniles are ingested by the next host (view diagram of the life cycle of *Nematodirus* spp.). The parasites can cause serious gastrointestinal upsets in infected hosts, resulting in severe diarrhea ("black scours") and significant economic losses. It has been estimated that annual losses in the US alone amount to more than $90 million in cattle and $20 million in sheep. Several species of trichostrongyles have been reported as occasional parasites of humans.

An egg of *Nematodirus*. Note the similarity to the eggs of the common species of hookworms. (Original image from the Michigan State University, College of Veterinary Medicine, OnLine Instructional Tutorial.)

A *Trichostrongylus* egg. (Original image from a Japanese language site tentatively title Internet Atlas of Human Parasitology.)

Cosmocerella sp.

The following two images depict the anterior and posterior ends of *Cosmocerella* sp.

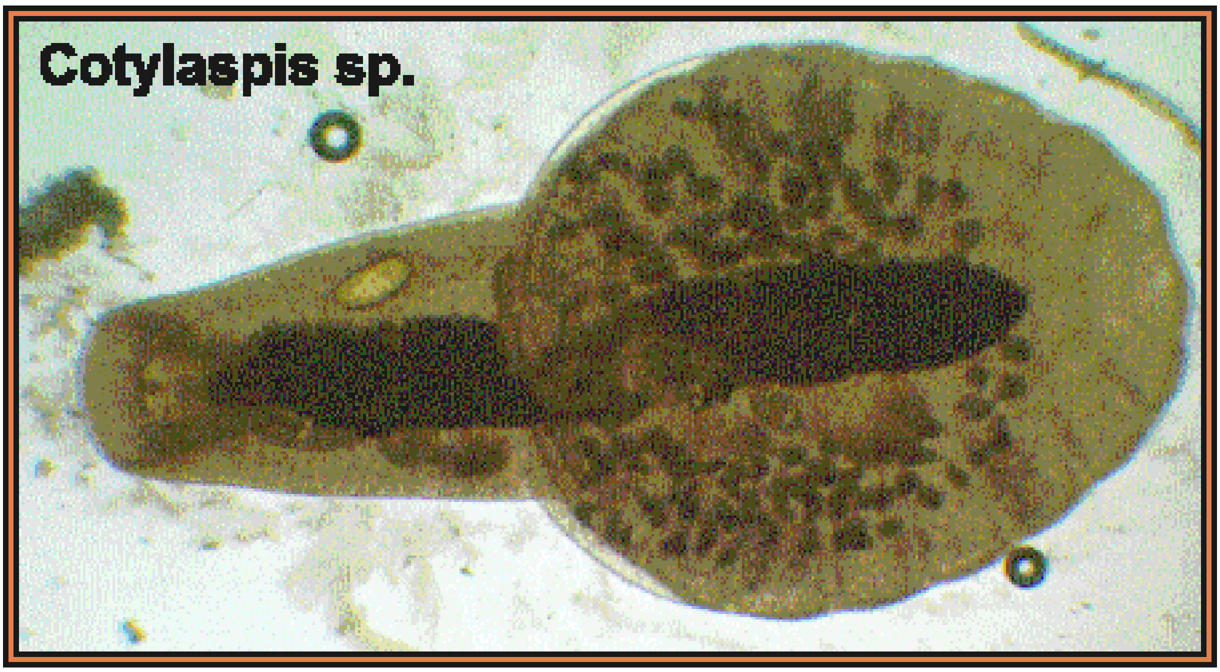
Graphic Images of Parasites

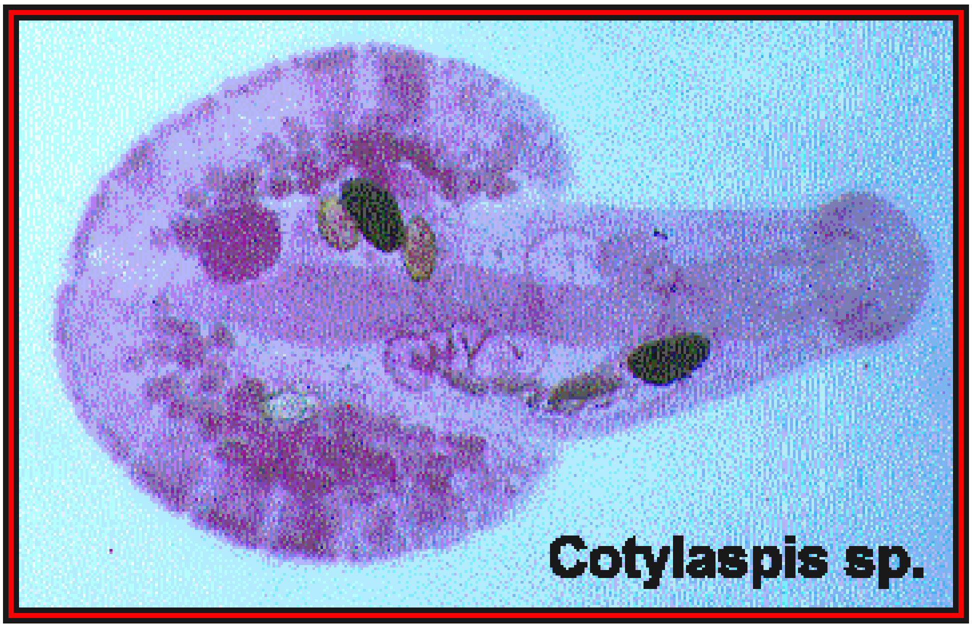
Cotylaspis sp.

Cotylaspis insignis is a parasite of clams. It resides in several different places within the host, including the gills, the suprabranchial cavities, or the junction of the foot and the inner gills. The parasite has a cosmopolitan distribution in rivers of the United States. Its life cycle is similar to that of *Aspidogaster* sp.

A whole mount of *Cotylaspis insignis*. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

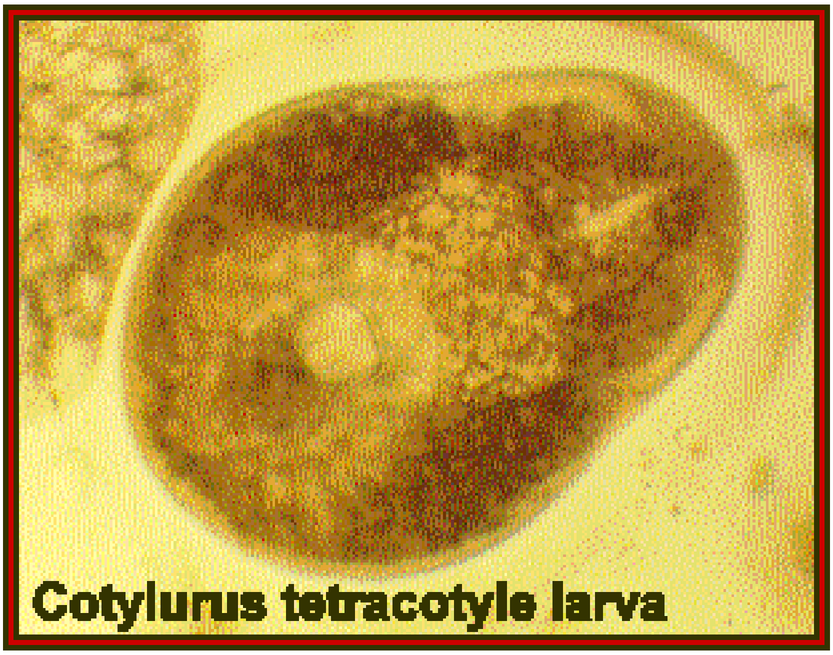
The following two images are of an unidentified species of *Cotylaspis*. The top image is unstained.



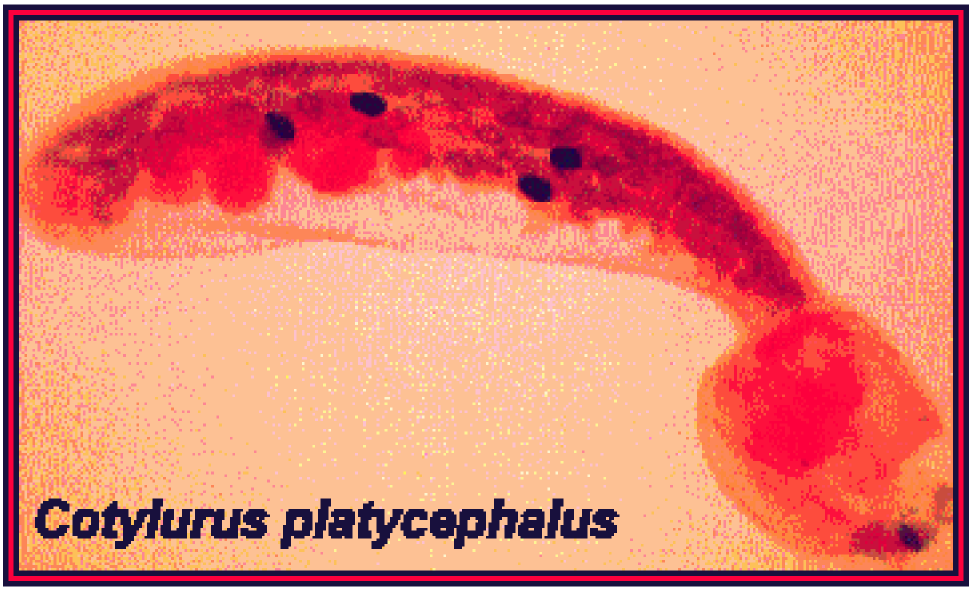

Cotylaspis sp.

Cotylurus sp.

The life cycles of most members of this genus are similar. The adult worms are found in the gut of the definitive host, often a bird, and eggs are passed in the feces. The first intermediate host is a snail, and a variety of animals can serve as the second intermediate host. The metacercarial stage of this parasite is often referred to as a "tetracotyle larva" or "tetracotyle metacercaria," and this stage is infective to the definitive host.



A tetracotyle larva (tetracotyle metacercariae) of *Cotylurus* sp. recovered from *Stagnicola* sp. (a snail).



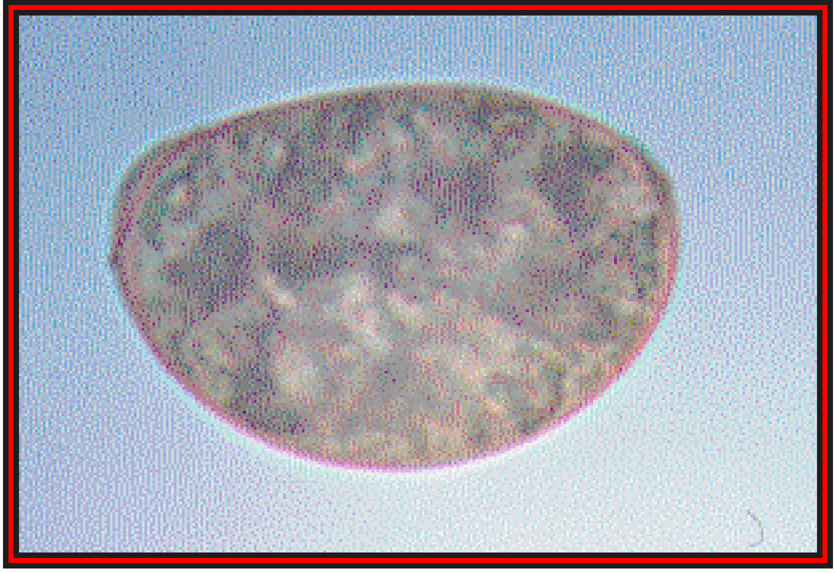
A whole mount of an adult *Cotylurus platycephalus*. The expanded "forebody" of this parasite, typical of many strigeids, is on the right side of the image.

Crepidostomum sp.

The life cycles of most species of *Crepidostomum* are similar. The adult parasites are found in the small intestine of the definitive host, a fish, and eggs are passed in the feces. The eggs hatch and the first intermediate host, a fingernail clam, is infected. Cercariae are liberated from the clam and infect the second intermediate host, a may fly naiad. The definitive host is infected when it ingests an infected second intermediate host.

A live specimen of *Crepidostomum* sp. photographed with transmitted light. Even in this unstained specimen, many of the internal organs are visible. Note also the characteristic shape of the oral sucker, similar to that of many species in the family Allocreadiidae.

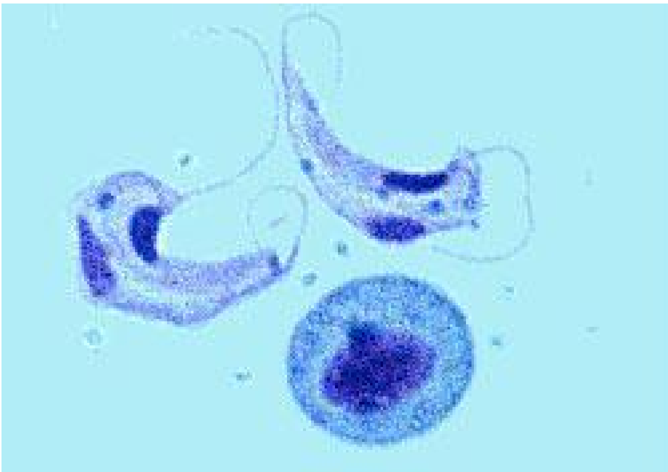
A stained whole mount of *Crepidostomum* sp. recovered from a yellow perch.


An egg of *Crepidostomum* sp.

Cryptobia sp.

Members of this genus of hemoflagellate have two flagella, one free and one forming an undulating membrane. Most members of this genus are parasites of invertebrates, but a few species are important parasites of fishes.

Cryptobia salmositica is a blood parasite of several teleosts, including all Pacific salmon. The flagellate is transmitted by leeches, although direct transmission has been reported to occur. The parasite can cause significant pathology in fish, including anorexia, hepatosplenomegaly, anemia, and distension of the abdominal cavity. Infected fish are probably more susceptible than uninfected fish to predation.



Cryptobia salmositica (Giemsa stain) from the blood of an infected rainbow trout. (Original figure by Dr. Patrick Woo, University of Guelph, and used with permission.)

Exophthalmia in a rainbow trout infected with *Cryptobia salmositica*. (Original image by Dr. Patrick Woo, University of Guelph, and used with permission.)

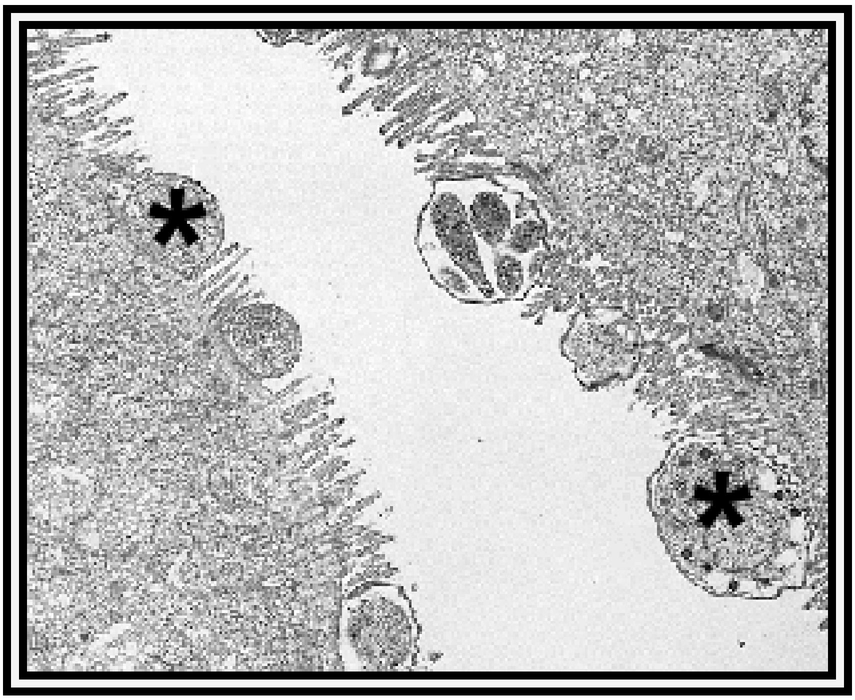
Abdominal distension (edema and ascites) in a rainbow trout infected with *Cryptobia salmositica*. (Original image by Dr. Patrick Woo, University of Guelph, and used with permission.)

Cryptosporidium parvum
(**cryptosporidosis**)

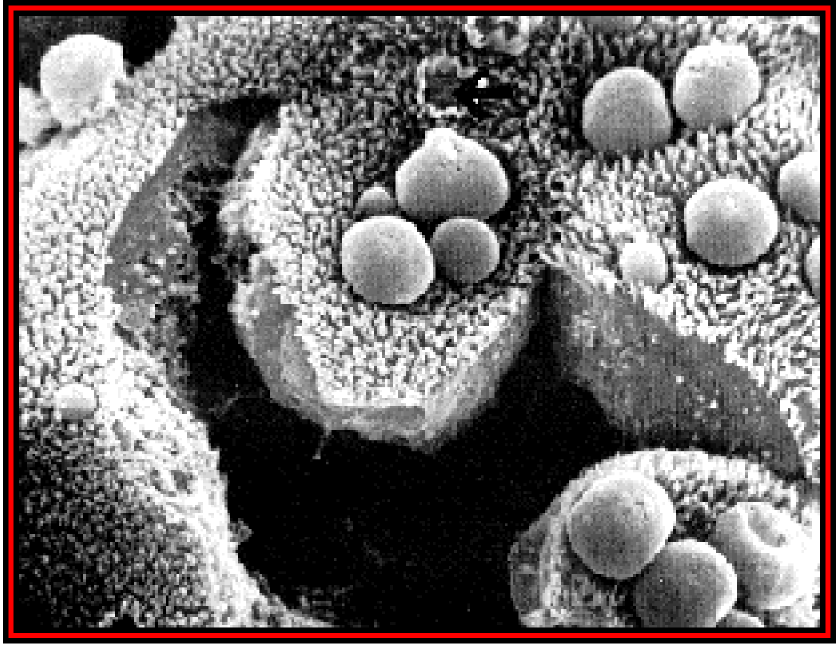
Members of the genus *Cryptosporidium* are parasites of the intestinal tracts of fishes, reptiles, birds, and mammals. It seems that members of this genus do not display a high degree of host specificity, so the number of species in this genus remains a matter of some discussion. *Cryptosporidium* isolated from humans is now referred to as *C. parvum*. *Cryptosporidium* infections have been reported from a variety of wild and domesticated animals, and in the last six or seven years literally hundreds of human infections have been reported, including epidemics in several major urban areas in the United States. Cryptosporidiosis is now recognized as an important opportunisitic infection, especially in immunocompromised hosts.

Cryptosporidium is a small parasite, measuring about 3-5 µm. It lives on (or just under) the surface of the cells lining the small intestine, reproduces asexually, and oocysts are passed in the feces (view diagram of the life cycle). Transmission of the infection occurs via the oocysts. Many human infections have been traced to the contamination of drinking water with oocysts from agricultural "run-off" (i.e., drainage from pastures), so it is considered a zoonosis.

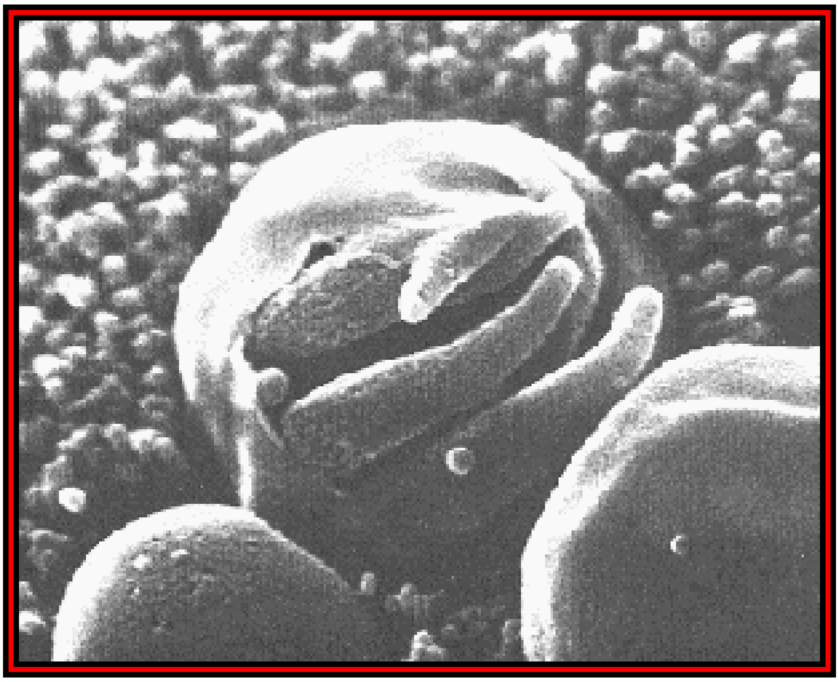
In most patients infected with cryptosporidiosis the infection causes a short term, mild diarrhea. Since such symptoms are associated with a number of ailments, infected individuals may not seek medical treatment, and the infection may subside on its own. Thus, it is difficult to say how many people are infected. On the other hand, in persons with compromised immune systems, this parasite can cause a pronounced, chronic diarrhea; in severe cases the infected individual may produce up to 15 liters/day of stools, and this may go on for weeks or months. Needless to say, such an infection, if not fatal unto itself, can exacerbate other opportunitistic infections common in immunocompromised hosts.



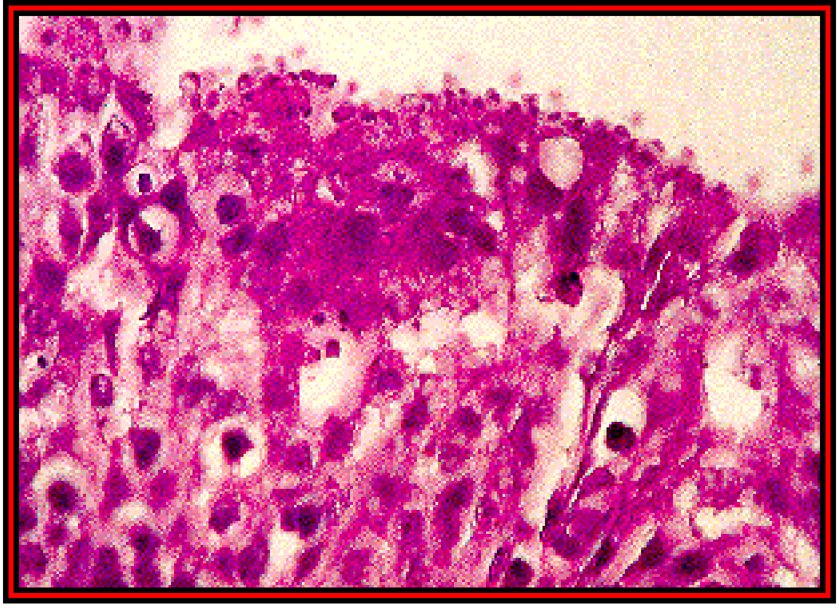
An electron micrograph showing several stages of *Cryptosporidium* (two are marked with asterisks) on the intestinal epithelium of a sheep. (From: Gardiner *et al.*, 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)



A scanning electron micrograph of *Cryptosporidium* lining the intestinal tract. (From: Gardiner *et al*., 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)

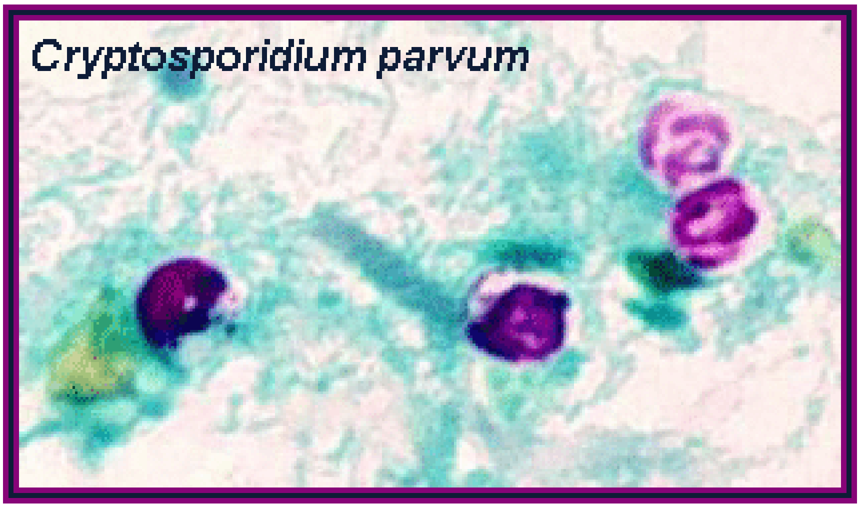


A scanning electron micrograph of a broken meront of *Cryptosporidium* showing the merozoites within. (From: Gardiner *et al*., 1988, An Atlas of Protozon Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)



The trachea of a turkey "lined" with numerous *Cryptosporidium*. (From: Gardiner *et al*., 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)

Cryptosporidium oocysts. (Original image from a Japanese language site tentatively titled Internet Atlas of Human Parasitology.)

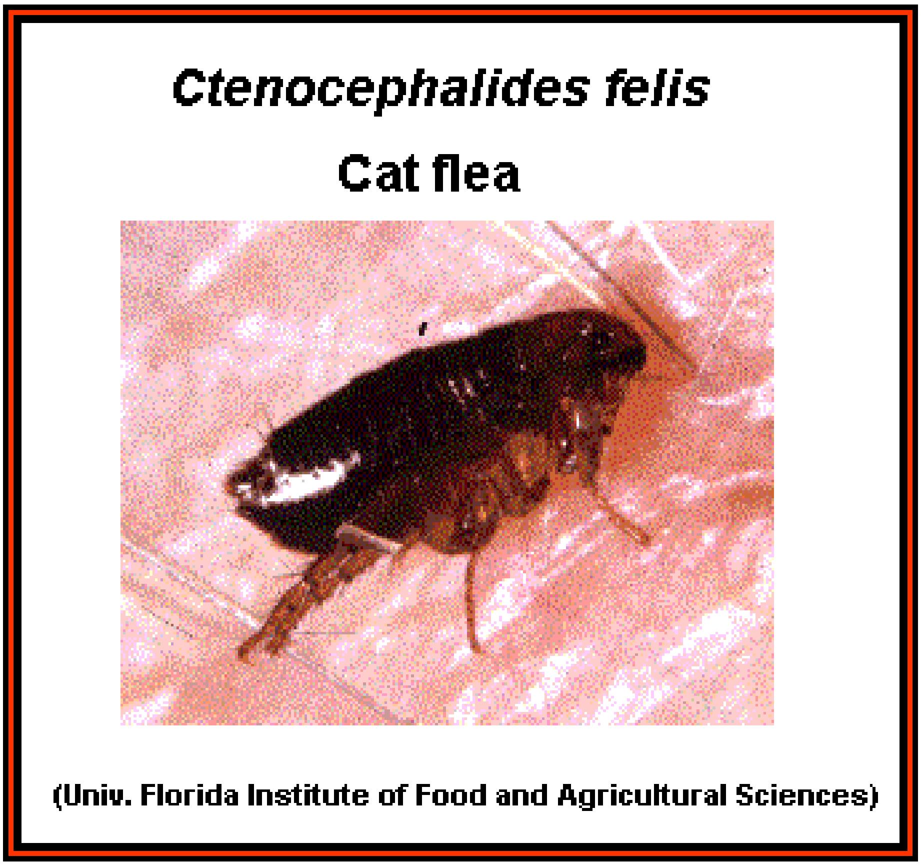


When stained using an acid-fast method, oocysts of *Cryptosporidium parvum* stain bright red or purple, as seen in this preparation. (Original image from DPDx [Identification and Diagnosis of Parasites of Public Health Concern], and used with permission.)

Graphic Images of Parasites

Ctenocephalides felis

Both the cat flea (*Ctenocephalides felis*) and its close relative the dog flea (*C. canis*) can be found on cats and dogs. Both will serve as the intermediate host for the tapeworm *Dipylidium caninum* ("cucumber tapeworm"). Infections with this tapeworm are often recognized by the presence of the tapeworm's proglottids (often referred to incorrectly as "segments"), which look like grains of rice, in the feces of dogs or cats. Humans are sometimes infected with this tapeworm; children are more likely to be infected since they are more likely to ingest a flea containing the tapeworm's immature stage (called a cysticercoid).



Ctenocephalides felis.

Cutaneous (dermal) larval migrans

There are several examples of parasites that are normally found in pets but can be transmitted to humans. For example, a common tapeworm of dogs, *Dipylidium caninum*, can be transmitted to humans. Immature forms of the common roundworm of dogs, *Toxocara canis* can also be found in humans, causing a disease known as visceral larval migrans. Immature forms of both cat and dog hookworms can also infect humans, and this results in a disease called cutaneous or dermal larval migrans (CLM or DLM).

The eggs of dog and cat hookworms hatch after being passed in the host's feces, and the next host is infected when these larvae penetrate the host's skin. Unfortunately, these larvae can not tell the skin of one animal from another, so they will penetrate human skin if they come in contact with it. However, a human is an unnatural host, so the larvae do not enter the blood stream as they would in a dog or cat. Rather, they remain in the skin for extended periods of time (weeks or months in some instances) and finally die. As the larvae migrate through the skin and finally die, there is an inflammatory response, and the progress of the larvae through the skin can actually be followed since they leave a tortuous "track" of inflammed tissue just under the surface of the skin. Treatment of such infections requires surgical removal of the migrating larvae. Considering the location of larvae, just under the skin, in light infections this can be done under local anesthesia and is a relatively simple procedure. Infections involving large numbers of larvae can be very uncomfortable, and treatment (removal) might require general anesthesia and supportive treatment with anti-inflammatory drugs.

How do humans come in contact with the larvae of dog and cat hookworms? A common source of infection in developed countries is probably sandboxes. If you have a sandbox in your backyard, it is almost certain that cats in the neighborhood are using it as a large litter box. Moreover, the sand provides a nearly ideal environment for the hookworm eggs to develop and hatch and for the larvae to survive. Thus, keeping sandboxes covered to prevent cats from defecating in them is a worthwhile "ounce of prevention." Other places where cats might defecate are also possible sources of infection, including flower beds and vegetable gardens. Dogs are much less fastidious about where they defecate, so it is more difficult to control dog feces as a possible source of infection. If you own a dog two measures that you should take are (1) keep you dog free of hookworms and (2) make sure that you clean up the dog's feces on a regular basis. Also, if you "walk" your dog in a park or playground, and in particular in my front yard, make sure that you pick up and dispose of any fecal material the dog might leave behind.

CLM of the foot.
(Original image from: Companion Animal Surgery.")

CLM of the foot.

(Original image from and copyrighted by Dermatology Internet Service, Department of Dermatology, University of Erlangen.)

CLM of the foot.

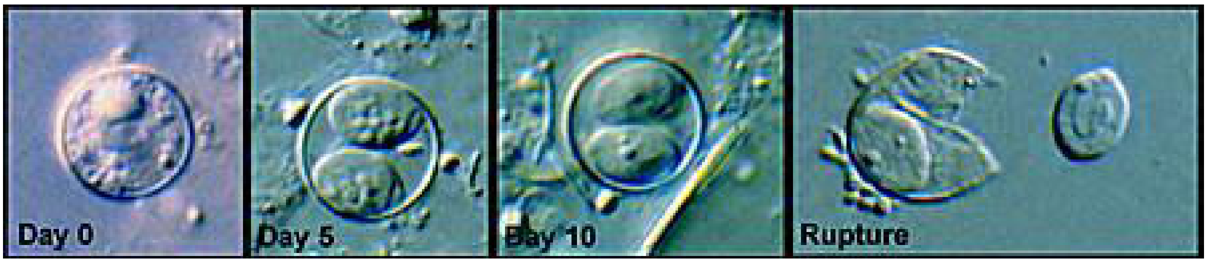
(Original image from and copyrighted by Dermatologic Image Database, Department of Dermatology, University of Iowa College of Medicine).

Cyclospora cayetanensis

Cyclospora cayetanensis infections in humans were first reported in the late 1970's, and since that time infections have been reported with increasing frequency. It is unknown if this parasite is found in animals other than humans. In many ways, the biology of this parasite resembles the biology of better known apicomplexan parasites such as *Eimeria* and *Isospora*.

The life cycle of *C. cayetanensis* is direct. The parasite lives in the cells of the host's small intestine. At first the parasite reproduces asexually, and the resulting merozoites infect more cells. It is this stage of the life cycle that is responsible for the symptoms and pathology associated with this parasite. This stage of the parasite's life cycle is also self-limiting, so in most cases the infection subsides spontaneously. Some of the merozoites will produce gametes which fuse and subsequently produce oocysts, and the oocysts are passed in the host's fecal material. After being passed in the feces, the oocysts become infective (sporulate) in one to two weeks. The next human is infected when he/she ingests food or water contaminated with oocysts (see diagram of life cycle). Several recent outbreaks of this parasite have been traced to fruits (various "berries") contaminated with human sewage, and it has been suggested that many cases of "traveler's diarrhea" might be caused by this parasite. As with most other parasites of the gastrointestinal tract, this parasite is diagnosed by finding oocysts in the patient's fecal material.

Symptoms associated with this parasite are variable and vague. Some infected humans apparently suffer no symptoms, while others suffer various degrees of diarrhea, gas, cramps, nausea, vomiting, and fever. In most instances these symptoms disappear in a few days, but in some cases the symptoms may last for months. Prescription drugs are available that will cure the infection. It is not known if humans with compromised immune systems (e.g., AIDS patients) suffer more serious symptoms.



Sequence of images showing the process of oocyst sporulation in *Cyclospora cayetanensis*. Upon being passed in the feces (day 0, left image), the oocyst is unsporulated and not infective. After 10 days the oocyst is sporulated and infective. Note the two sporocysts, each of which contains sporozoites, in the sporulated oocyst. (Original image from DPDx Identification and Diagnosis of Parasites of Public Health Concern.)

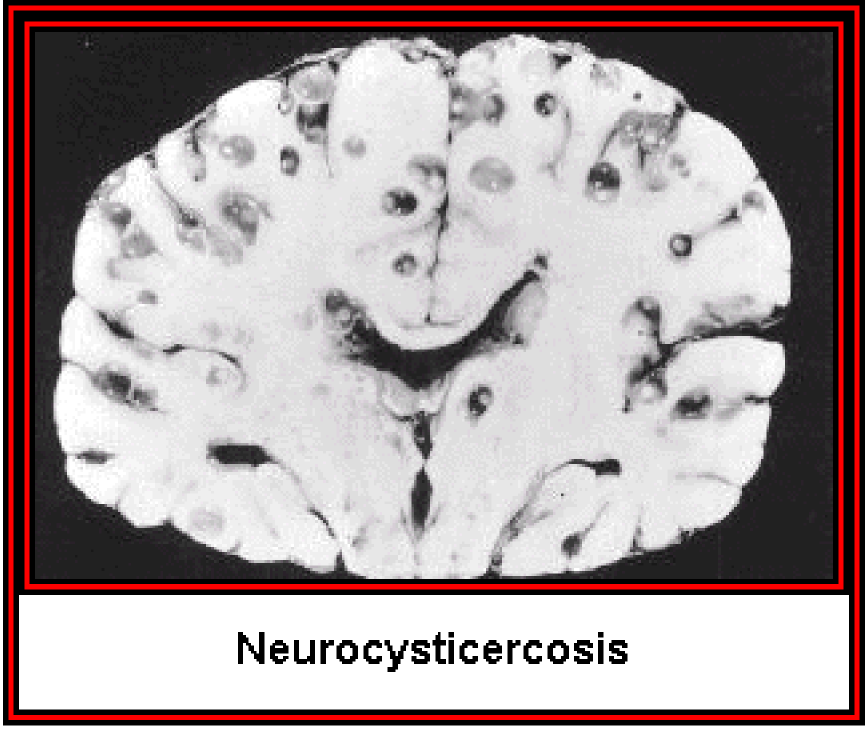
Cysticercosis

Pigs normally serve as the intermediate host for the pork tapeworm, *Taenia solium*, and humans are infected with the adult stage of the tapeworm when they ingest an immature tapeworm (a cysticercus) in raw or undercooked pork. However, if humans ingest eggs of *T. solium*, they can be infected with cysticerci, resulting in a condition known as cysticercosis. What might be the source of these eggs? Humans harbor the adult stage of this tapeworm, and it is the adult stage that produces eggs. Thus, many cases of cysticercosis probably result from a person ingesting eggs that are produced by a tapeworm living in his or her own intestinal tract. Poor personal hygiene is one obvious way in which this could occur. It is also possible for the proglottids of *T. solium* to migrate anteriorly from the small intestine into the stomach and then back into the small intestine. Should this occur the eggs in the proglottids would hatch resulting in the potential for a massive infection of cysticerci. People can also be infected via food contaminated with eggs, or via eggs present in a household or work environment. Since the tapeworm's proglottids can crawl out of the anus and contaminate clothing, furniture, etc., or drop to the ground, such contamination could occur in the absence of any visible source of "fecal" contamination.

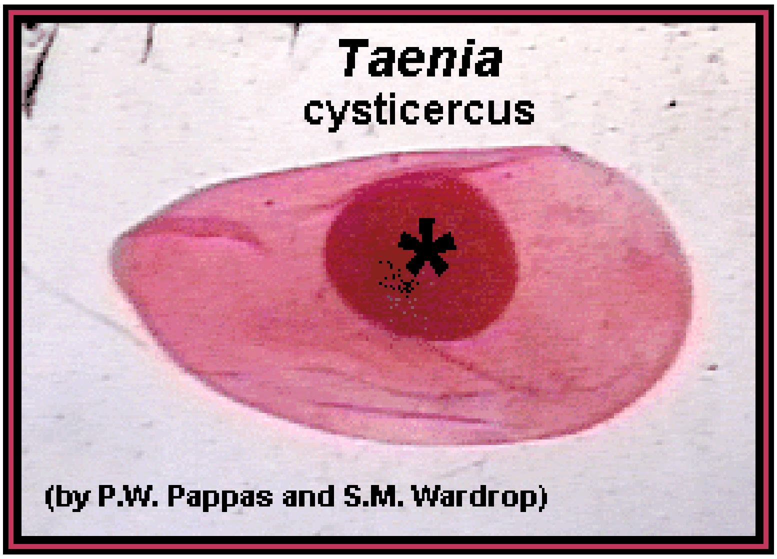
Once the eggs hatch in the human's small intestine, the larvae penetrate the lining of the small intestine and enter the blood stream. From here the larvae can be distributed to any organ in the body. The larvae then grow into the metacestode stage, a cysticercus. Mature cysticerci can range in size from 5 mm in diameter up to 20 cm (almost 8 inches!) in diameter.

The pathology associated with cysticercosis depends on which organs are infected and the number of cysticerci. A infection consisting of a few small cysticerci in the liver or muscles would likely result in no overt pathology and go unnoticed. In fact, many cases of human cysticercosis are discovered only during routine autopsies. On the other hand, even a few cysticerci (perhaps only one), if located in a particularly "sensitive" area of the body, might result in irreparable damage. For example, a cysticercus in the eye might lead to blindness, a cysticercus in the spinal cord could lead to paralysis, or a cysticercus in the brain (neurocysticercosis) could lead to traumatic neurological damage. **Thus, even though infections with adult *T. solium* are rarely a problem, treatment of such infections is absolutely essential.**

Historically, diagnosis of cysticercosis has been difficult. However, there are now several immunological tests available that will detect the presence of cysticerci, and improved imaging techniques such as CAT and MRI can be very useful in detecting cysticerci in various organs.

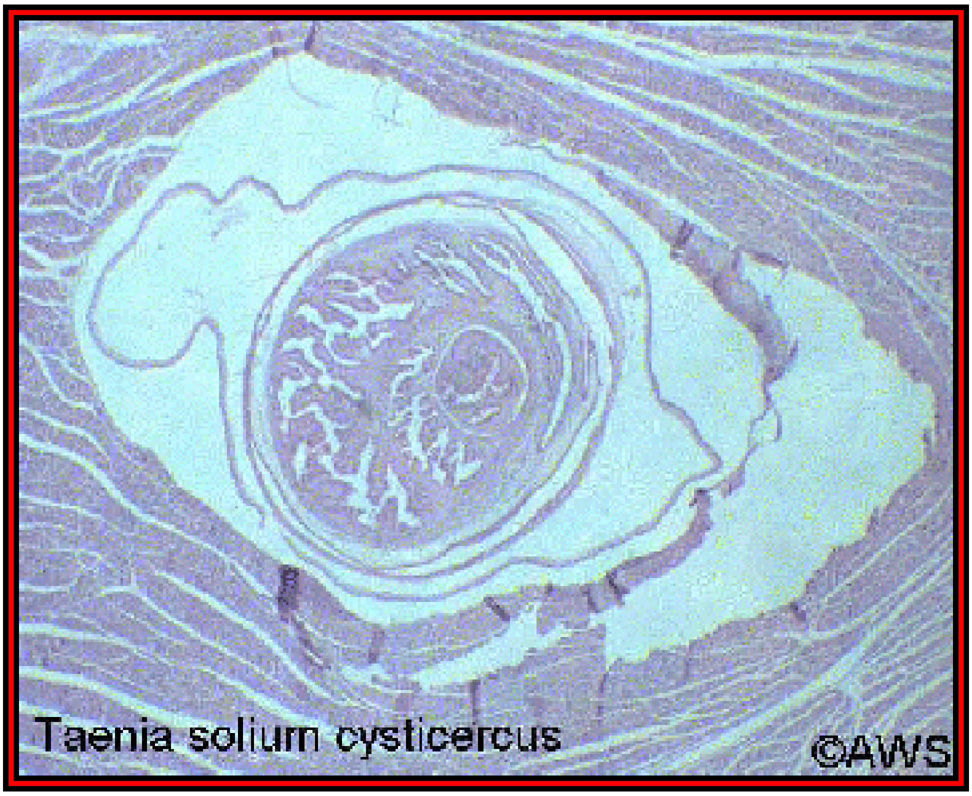


Section of a human brain containing numerous *Taenia* cysticerci. (Original image by Ana Flisser, UNAM, Mexico. Used with permission of Javier Ambrosio, UNAM, Mexico.)



A stained whole mount of a cysticercus. The cysticercus measures approximately 5 mm in length, and the scolex is marked with an asterisk.

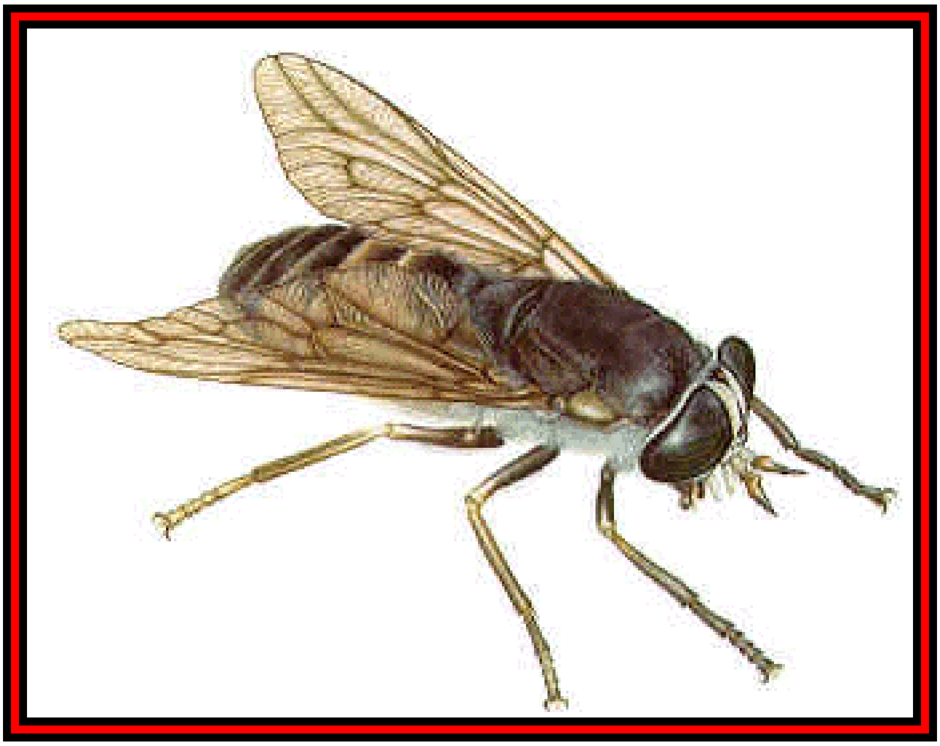
A tissue section of a cysticercus in muscle. Note the fibrotic capsule (*) around the cysticercus.



Another example of a cysticercus (*Taenia solium* = *Cysticercus cellulosae*) in the tissues of the intermediate host. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Tabanus and *Chrysops* spp.
(horse and deer flies)

Horse and deer flies serve as vectors for many diseases of humans and animals. Members of the genus *Chrysops* serve as vectors for *Loa loa* in humans. Members of the genus *Tabanus* serve as biological vectors for the blood parasite *Trypanosoma theileri* (in cattle), as mechanical vectors for the blood parasites *Trypanosoma evansi* (causing surra in camels, horses, and additional animals) and *Trypanosoma equinum* (causing mal de Caderas in horses), and as biological vectors for the filarial parasite *Elaeophora schneideri*. *Tabanus* spp. also serve as vectors for the diseases caused by bacteria and viruses.



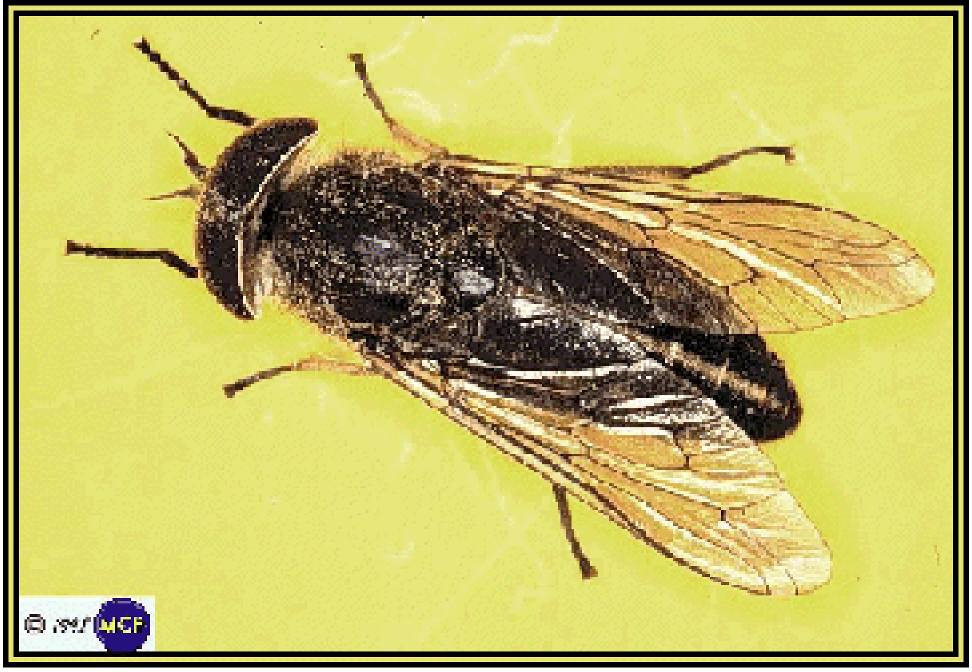
Tabanus sp., a vector for many parasites of humans and animals.

An adult horse fly (*Tabanus* sp.) (Original image from "Featured Creatures" and copyrighted by the University of Florida).

An adult deer fly (*Chrysops.* sp.) laying eggs. (Original image from "Featured Creatures" and copyrighted by the University of Florida).

An adult deer fly (*Chrysops* sp.) preparing to feed. (Original image from "Featured Creatures" and copyrighted by the University of Florida).

The following two images of "tabanid" flies show the characteristic eyes which cover most of the fly's head. (Original images from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

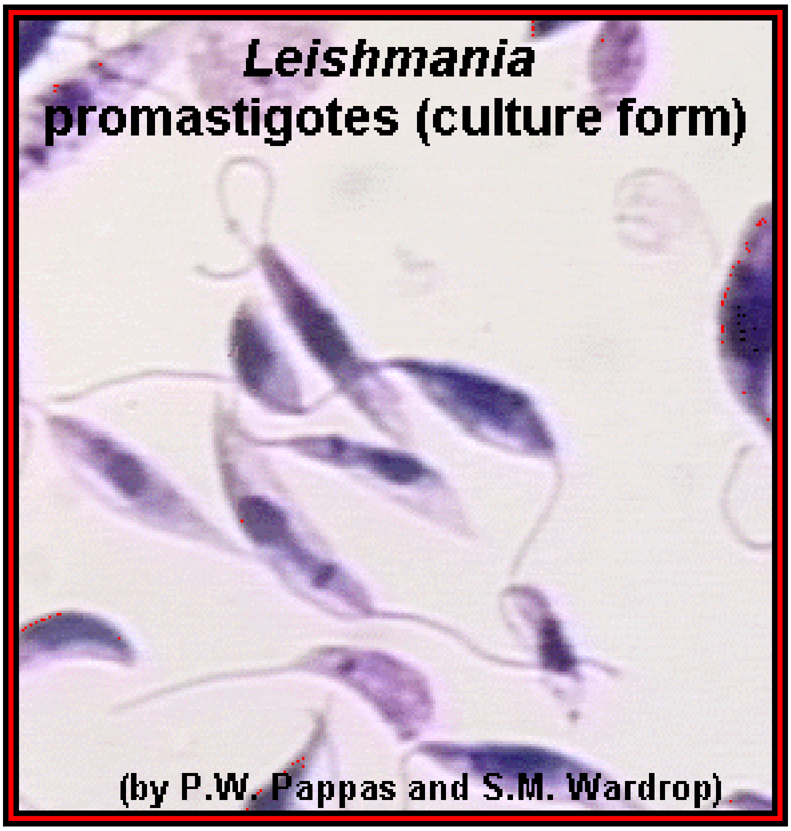


Graphic Images of Parasites

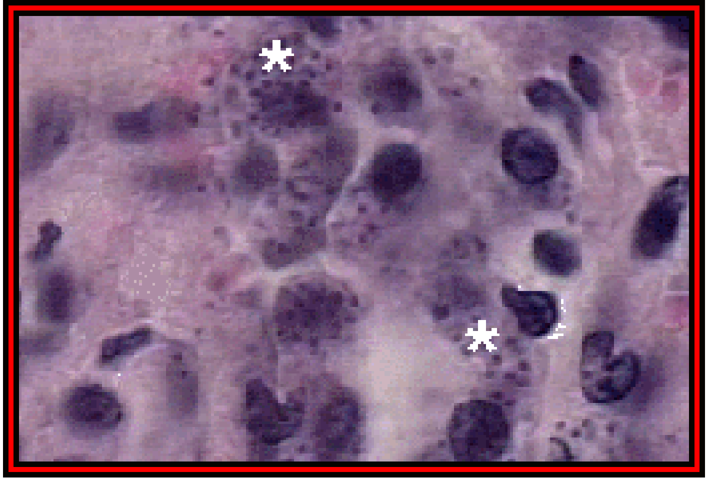
Leishmania spp.
(leishmaniasis)

Members of the genus *Leishmania* infect many vertebrates, including humans, dogs, and rodents. The life cycles of members of the genus involve a vertebrate host (e.g., the human) and a vector (a sand fly) that transmits the parasite between vertebrate hosts. In the vector the parasite takes on a characteristic morphological form known as the promastigote (see below), and it reproduces asexually in the vector's gut. When the vector bites the vertebrate host, promastigotes are injected into the vertebrate host. The promastigotes enter cells of the vertebrate host and change into a form called the amastigote (see below). The amastigote reproduces in the host's cells, and when the cell eventually dies the amastigotes are released and infect other cells (view a diagram of the life cycle). The symptoms and pathology associated with leishmaniasis result from the amastigotes killing the host's cells.

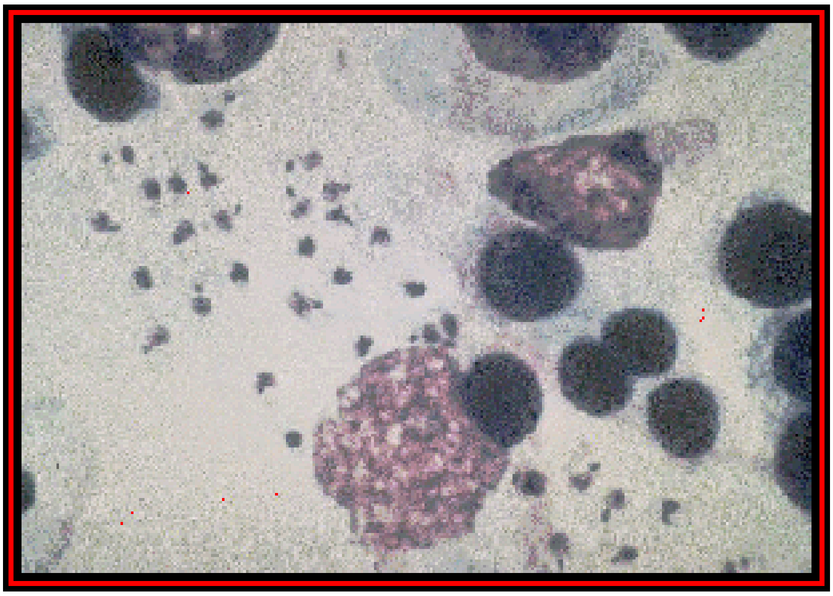
There are many different "diseases" caused by *Leishmania*. In some diseases the amastigotes do not spread beyond the site of the vector's bite. This results in a "cutaneous leishmaniasis" (oriental sore, Jericho boil, Aleppo boil, or Dehli boil) that often heals spontaneously (view geographic distribution). In other instances the amastigotes may spread to the visceral organs (liver, spleen), resulting in "visceral leishmaniasis" (kala-azar or Dum-Dum fever) (view geographic distribution) or to the mucous membranes of the mouth and nose, resulting in "mucocutaneous leishmaniasis" (espundia or uta). Left untreated, these latter diseases result in high rates of mortality. The various types of leishmaniasis are confined primarily, but not exclusively, to Central and South America, central Africa, and parts of southern and central Asia.



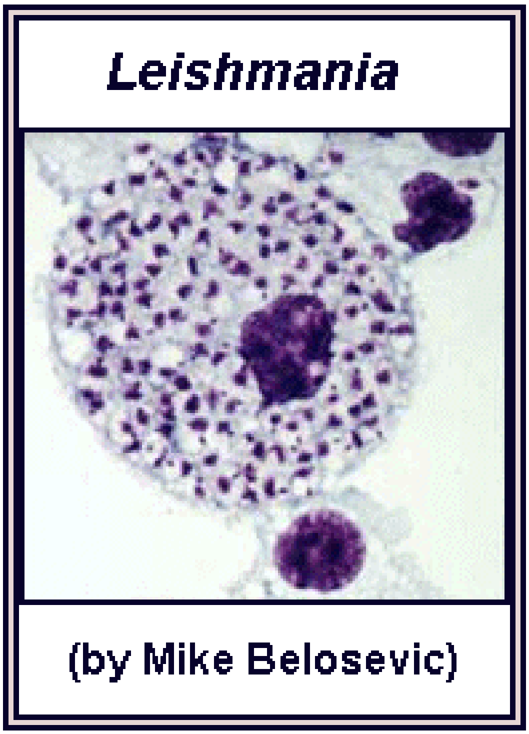
Promastigotes of *Leishmania* sp. from culture. This is the life cycle stage that grows in the vector and that is injected into the human host when the vector feeds. The promastigotes are approximately 25 µm in length.



Amastigotes (*) of *Leishmania donovani* in the cells of a spleen. The individual amastigotes measure approximately 1 µm in diameter. The amastigotes reproduce asexually in these cells.



Amastigotes of *Leishmania* in a macrophage from a lymph node of a dog. Original image from [Oklahoma State University Parasitology Teaching Resources Web Site](#).)



A macrophage filled with *Leishmania* amastigotes.

A cutaneous leishmaniasis lesion on the arm.

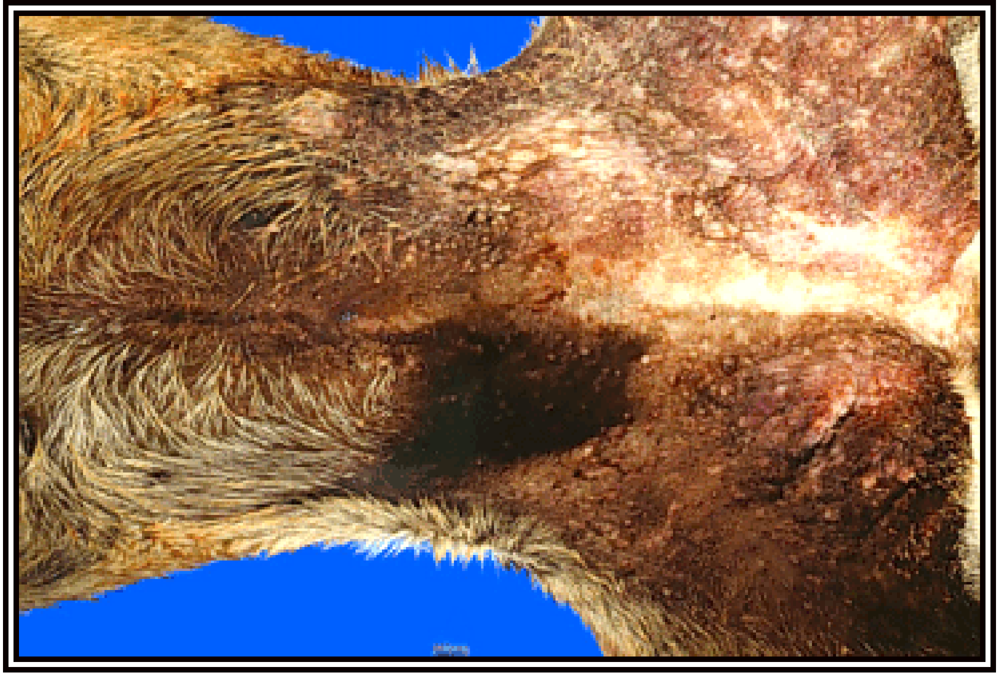
Cutaneous leishmaniasis of the face. (Original image from and copyrighted by [Dermatology Internet Service, Department of Dermatology, University of Erlangen](#).)

Demodex spp.
(follicle mites)

Follicle mites infect many species of mammals, and they seem to have a high degree of host specificity (i.e., mites from one host species will not infect another host species). Humans are infected with two species of follicle mites, *D. folliculorum*, which lives in hair follicles, and *D. brevis*, which lives in sebaceous (oil) glands. Both of these species are found most commonly in the hair follicles and oil glands of the face (particularly in and around the nose, eyes, and forehead). This mite can occur in a high percentage of the population (nearly 100% in older people), but, fortunately, these species do not usually cause "problems." In those cases in which follicle mites do cause problems, they are most often associated with skin rashes, hair loss (particularly the eyelashes), and acne.

In other animals, infections with follicle mites can be more serious. Dogs are infected with *D. canis* (the dog follicle mite), which can cause red mange or canine demodectic mange. This mite can cause severe skin problems in infected dogs, including significant loss of hair and skin rashes, and in some cases infected dogs must be euthanized.

Demodex sp., the human follicle mite. Despite its ferocious appearance, the mite is quite small (0.1 to 0.4 mm), and it usually causes no problems. (Modified after an original image from the University of South Africa Department of Life Sciences.)



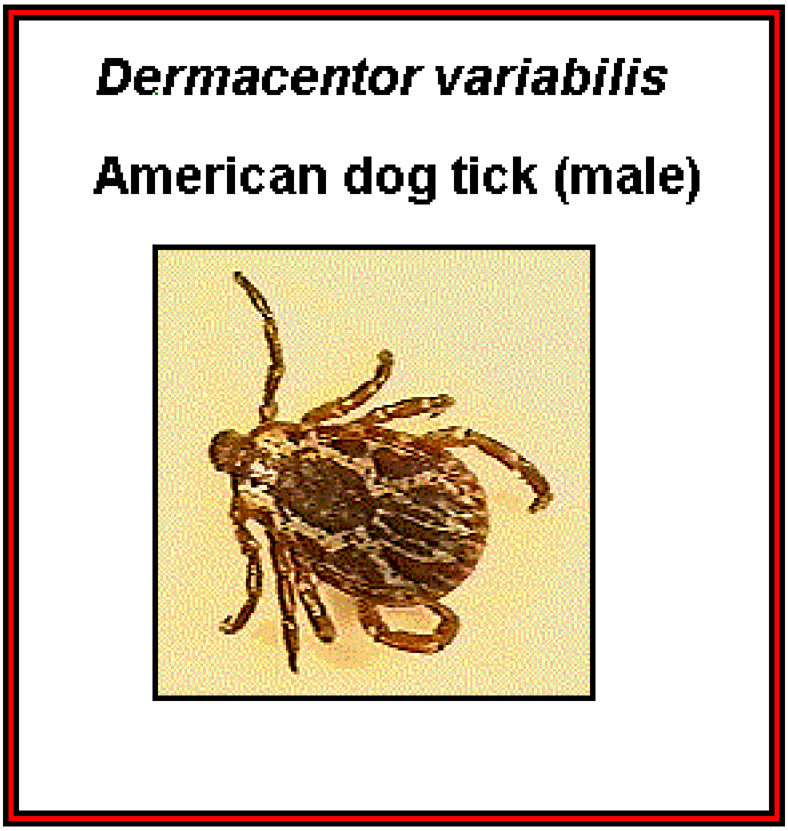
A severe case of canine demodectic mange caused by *Demodex canis*. (Original image from the Oklahoma State University Vet. Path. 5425 Home Page.)

Dermacentor sp.
(American dog tick)

The American dog tick, *Dermacentor variabilis*, and its relative the Rocky Mountain wood tick, *Dermacentor andersoni*, are vectors for several human diseases, including Rocky Mountain spotted fever and tularemia.

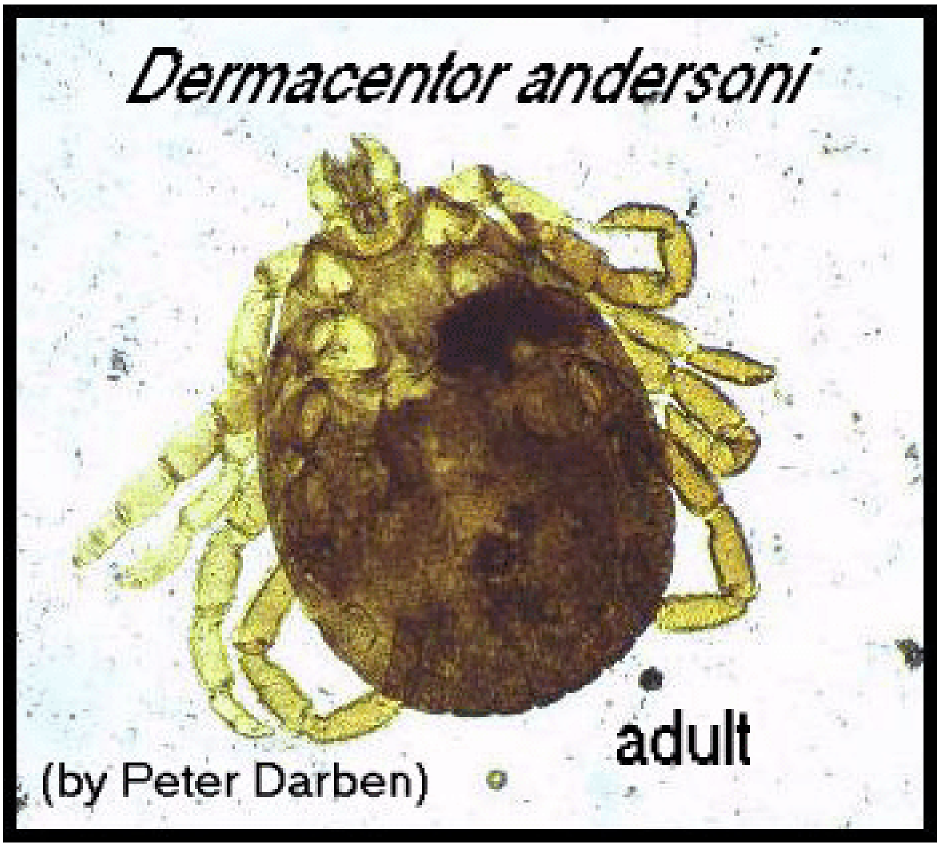
Dermacentor variabilis (male).

Dermacentor variabilis (female)



Dermacentor variabilis (male). Original image from and copyrighted by the Iowa State University Entomology Image

Gallery. Used with permission.

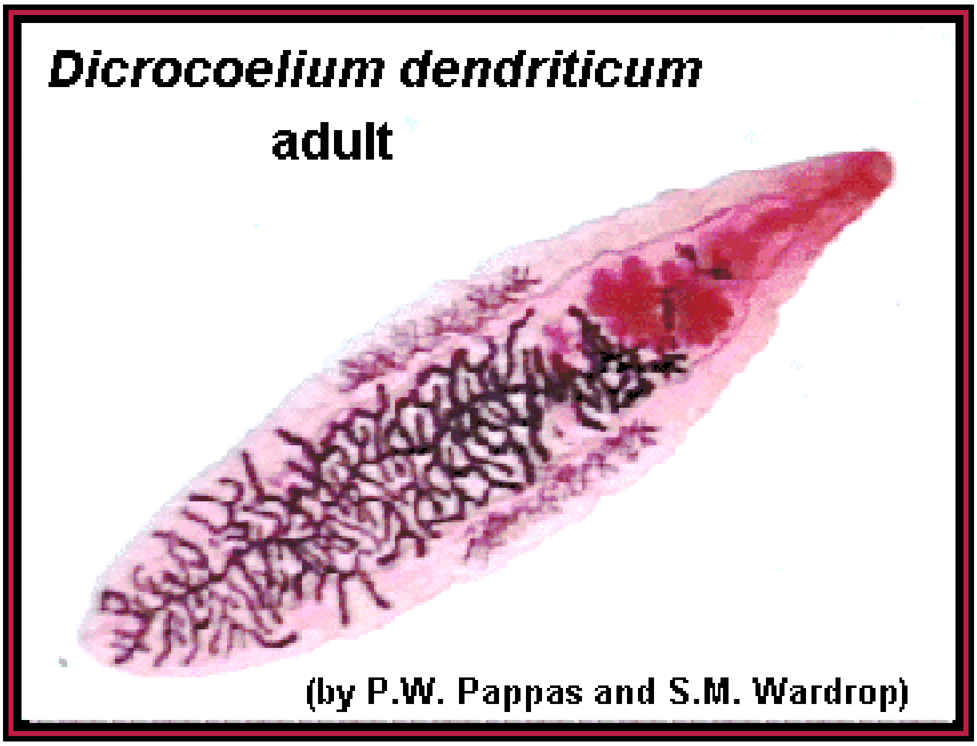


Dermacentor andersoni

Graphic Images of Parasites

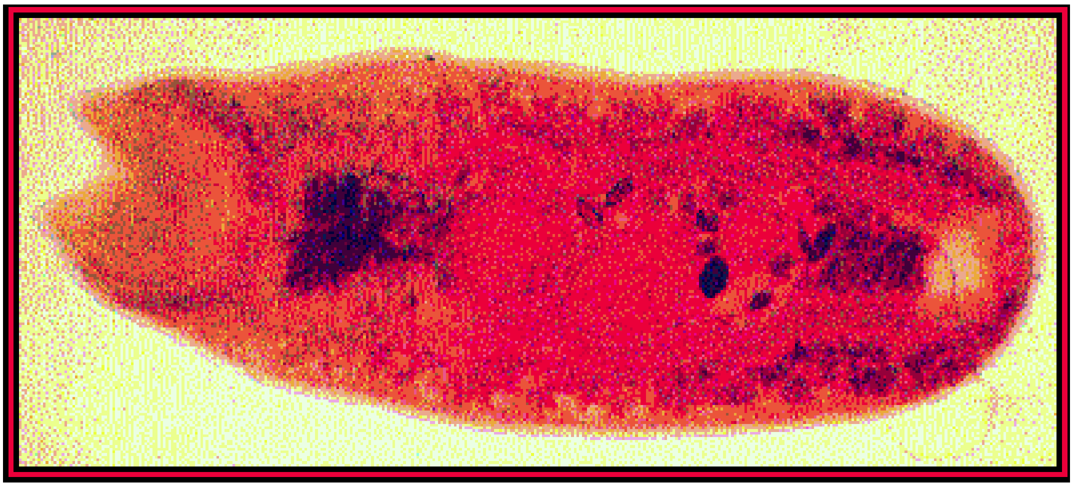
Dicrocoelium dendriticum
(the lancet liver fluke)

Dicrocoelium dendriticum is called the lancet liver fluke because of its characteristic shape. Unlike most other digenetic trematodes whose life cycles involve aquatic or marine hosts, the life cycle of this parasite is completely terrestrial involving a terrestrial snail as the first intermediate host and an ant as the second intermediate host. The definitive host, which includes sheep, cattle, goats, pigs, and humans (rarely), is infected when it ingests ants that are infected with metacercariae (view diagram of the life cycle). In the definitive host the parasite migrates into the bile duct and causes pathology similar to that caused by *Clonorchis sinensis*. This parasite is distributed throughout much of Europe and Asia, and it is also found in parts of North America and Australia.

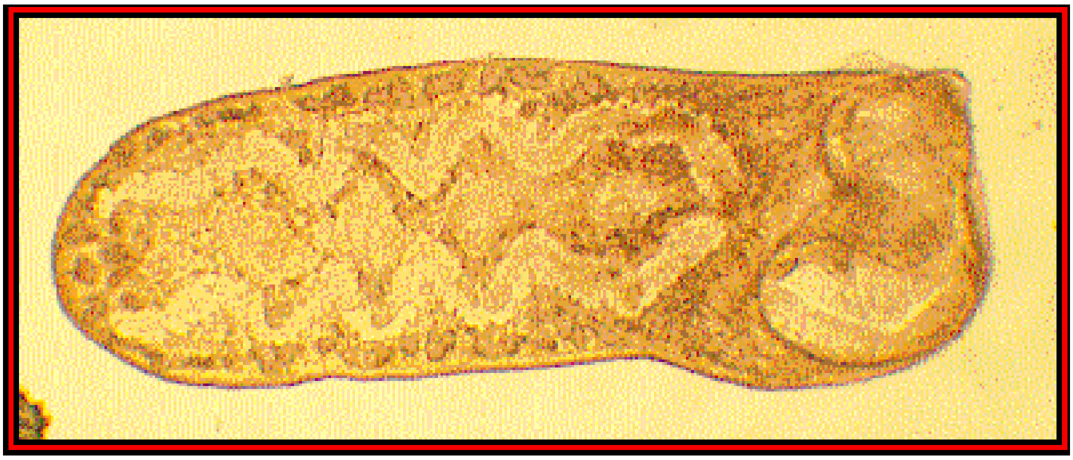


Dicrocoelium dendriticum, adult, stained whole mount; approximate size = 9 mm in length. Click here to view an image of this parasite in which the internal organs are labeled.

Dictyangium sp.



A stained whole mount of *Dictyangium* sp. recovered from a turtle.



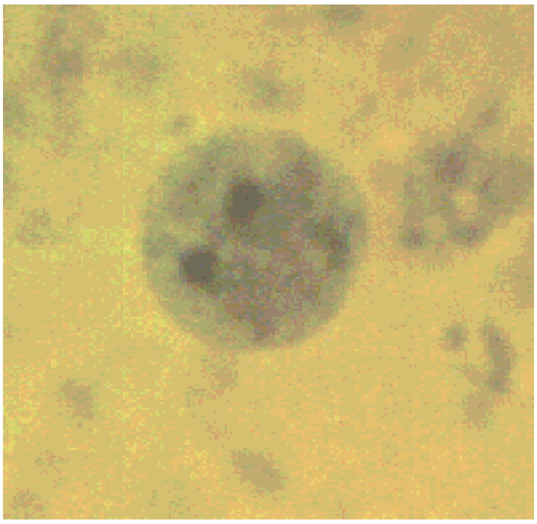
A live specimen of *Dictyangium* sp. recovered from a turtle.

Dientamoeba fragilis

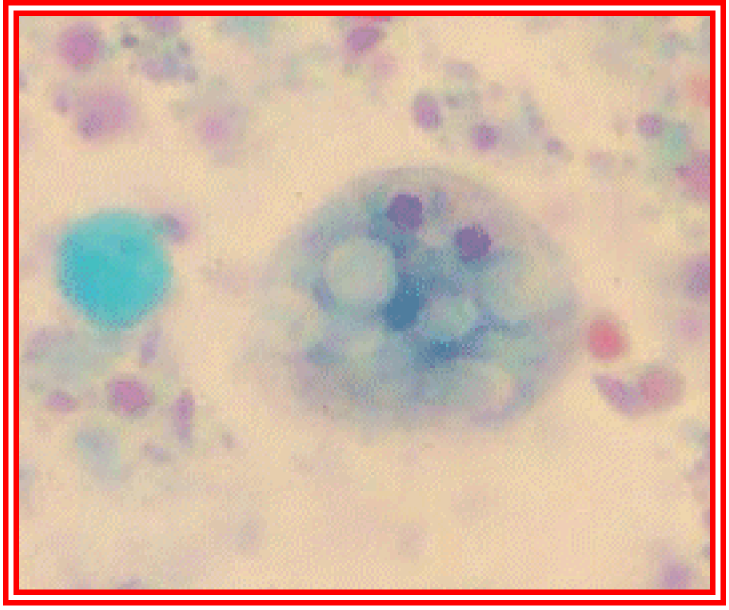
(a commensal ??)

Dientamoeba fragilis trophozoites live the large intestine of humans. No cyst stage has been reported for this species, so the exact mechanism of transmission remains unclear, but there is evidence that this organism is, in fact, transmitted among humans in the eggs of human pinworms (i.e., *Enterobius vermicularis*). The presence of *D. fragilis* is associated with mild, chronic gastrointestinal "upsets" (abdominal pain, gas, diarrhea, etc.) in about 25% of humans who harbor this species, but since this species often occurs with others (e.g., *Entamoeba histolytica* or *Giardia lamblia*), it is difficult to say with certainty which species is responsible for what. Even if this species is not a true pathogen, its presence should not be taken lightly, since it indicates that the infected human has been exposed to human fecal material or to pinworm eggs.

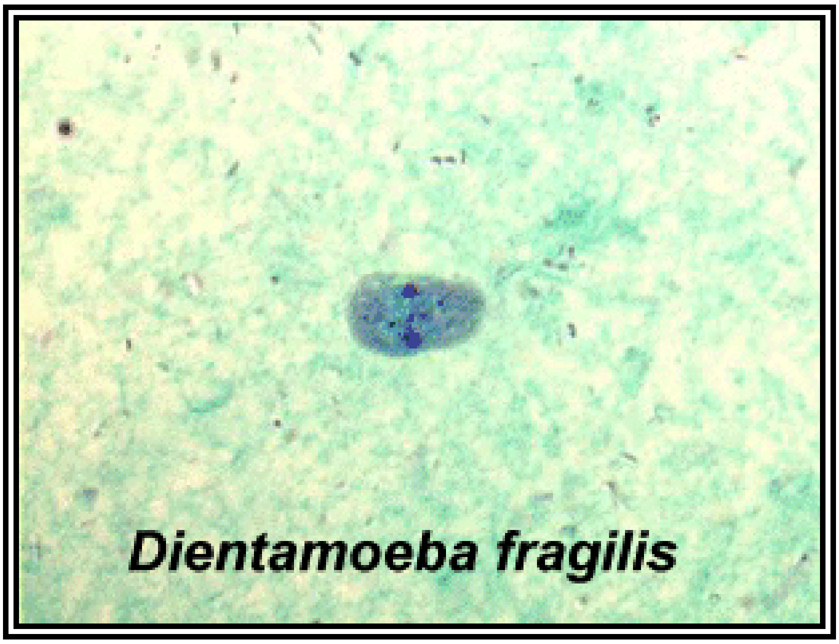
D. fragilis is one of the smallest parasites of the human gastrointestinal tract and, therefore, difficult to identify in fecal samples. One of the key features used to differentiate this species is the presence of two nuclei (the origin of the name, "dientamoeba"), but even this is not a particularly good character since only about 60% of the trophozoites have two nuclei.



A trophozoite of *Dientamoeba fragilis*. The two nuclei of this troph are visible. (Image provided by Rodrigo Alves de Fonseca, Universidade de Brasilia, Departmento Patologia.)



Dientamoeba fragilis, trichrome stain. (Original image from Department of parasitology, Chiang Mai University, and used with permission.



Dientamoeba fragilis. (Modified from an original image from "Parasitological Diagnostics Aids Page.")

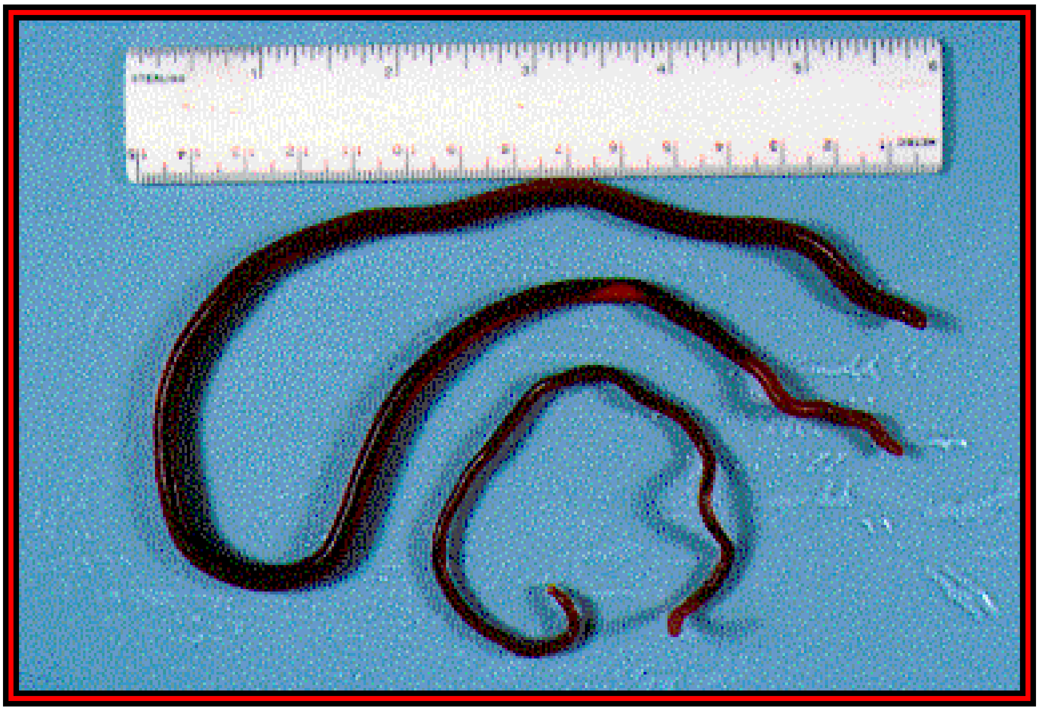
Graphic Images of Parasites

Dioctophyme renale
(giant kidney worm)

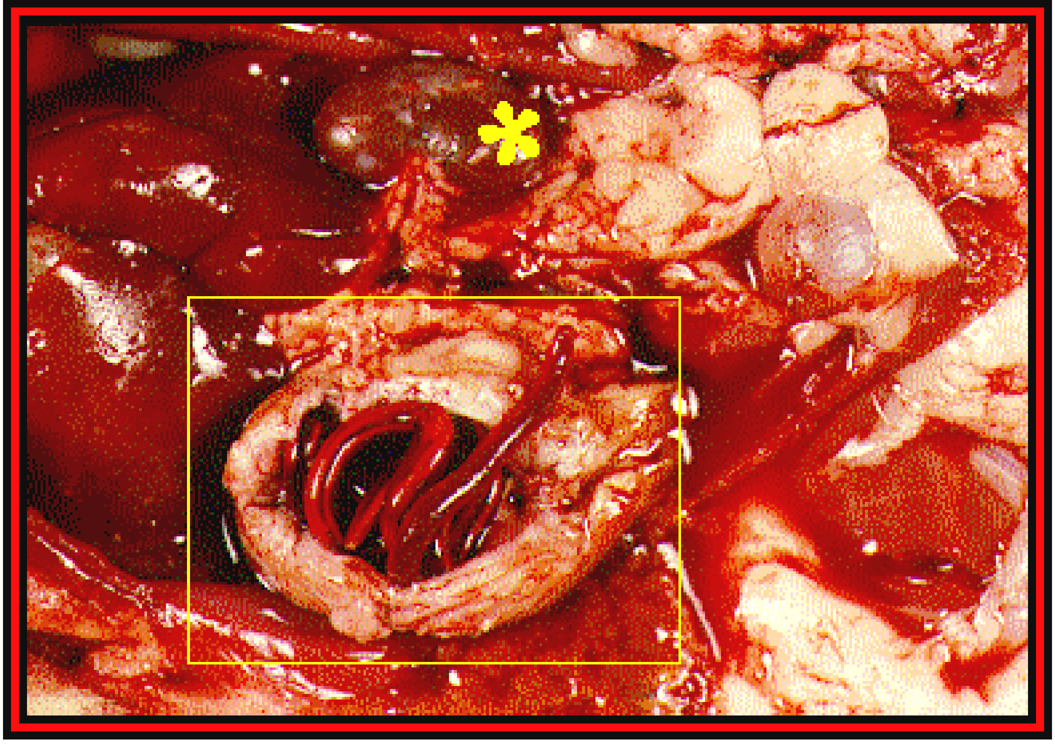
There appears to be a bit of confusion about the spelling of the generic name of this parasite, as it is sometimes spelled *Dioctophyma*. The common name of this parasitic nematode, "giant kidney worm," is well deserved, as the males can measure 20 cm long (6 mm wide) and the females can measure 100 cm long (12 mm wide). This species seems to lack host specificity, as it will infect many species of mammals, including humans. The male and female worms live in the kidney of the vertebrate host, and eggs are passed in the host's urine. The eggs are eaten by an aquatic annelid, and the parasite develops into an infective juvenile in the annelid. The vertebrate host is infected when it eats an infected annelid, or when it eats a fish or amphibian that serves as a paratenic host (click here for a diagram of the life cycle).

Considering the size of the worms and their location in the body, it is not surprising that this parasite can cause considerable damage. In serious infections the kidney is reduced to little more than a capsule, and the loss of renal function can be lethal. The only treatment for this parasite is surgical removal.

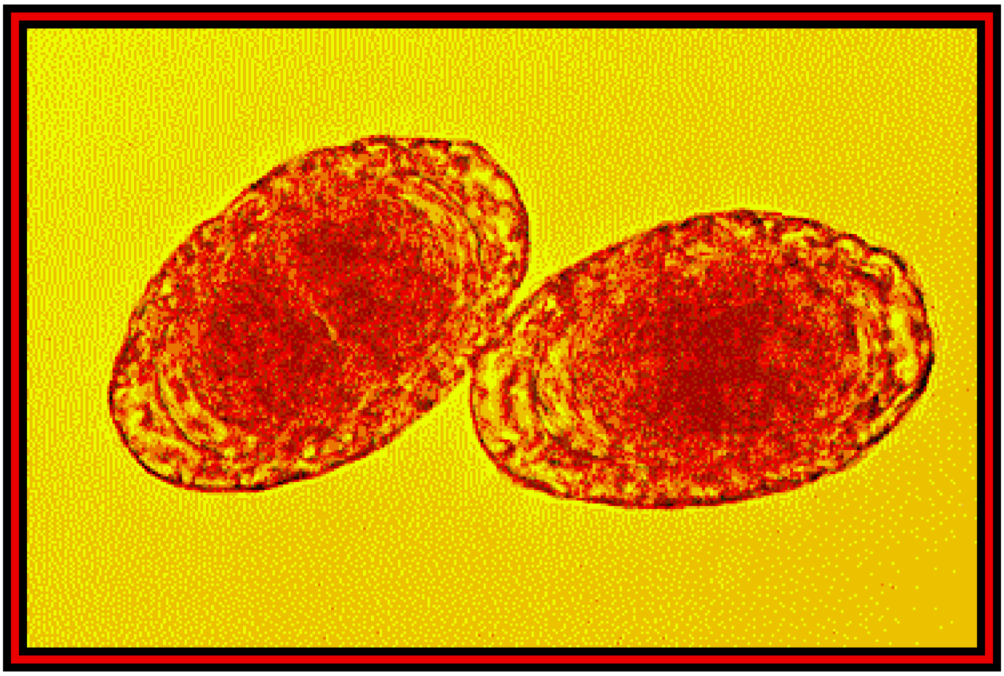
Unless indicated otherwise, the following images were scanned from slides provided by Dr. Lena Measures, Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, QC, Canada, and used with permission. Some of the scanned images were modified slightly for this web site.



Dioctophyme adults. Note the ruler (150 mm). The female worm is at the top of the image.



The abdominal cavity of a ferret infected experimentally with *Dioctophyme*. Note the worms in the right kidney (yellow square) and the hypertrophied left kidney (yellow asterisk).



Fertilized eggs of *Dioctophyme renale* from an experimentally infected ferret.

Another example of an egg of *Dioctophyme renale*. (Original image from [Oklahoma State University Parasitology Teaching Resources Web Site].

Histological section of *Dioctophyme renale* (*****) in a naturally infected pumpkin fish (*Lepomis gibbosus*).

Graphic Images of Parasites

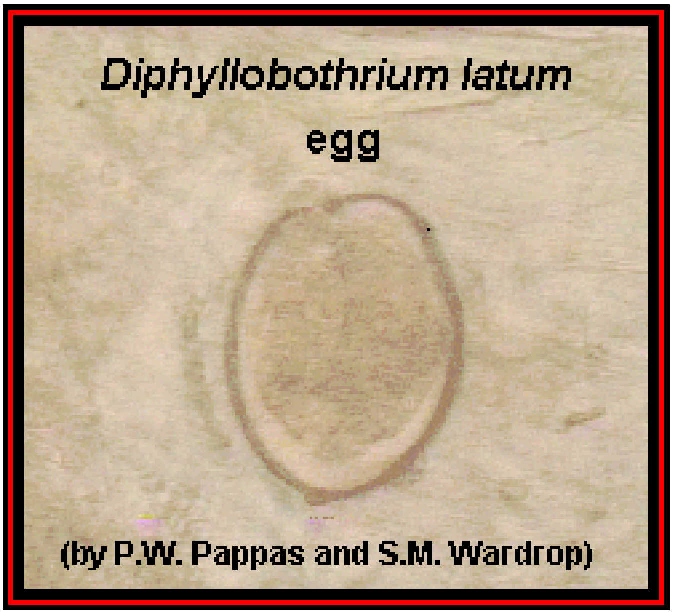
Diphyllobothrium latum

(the broadfish tapeworm)

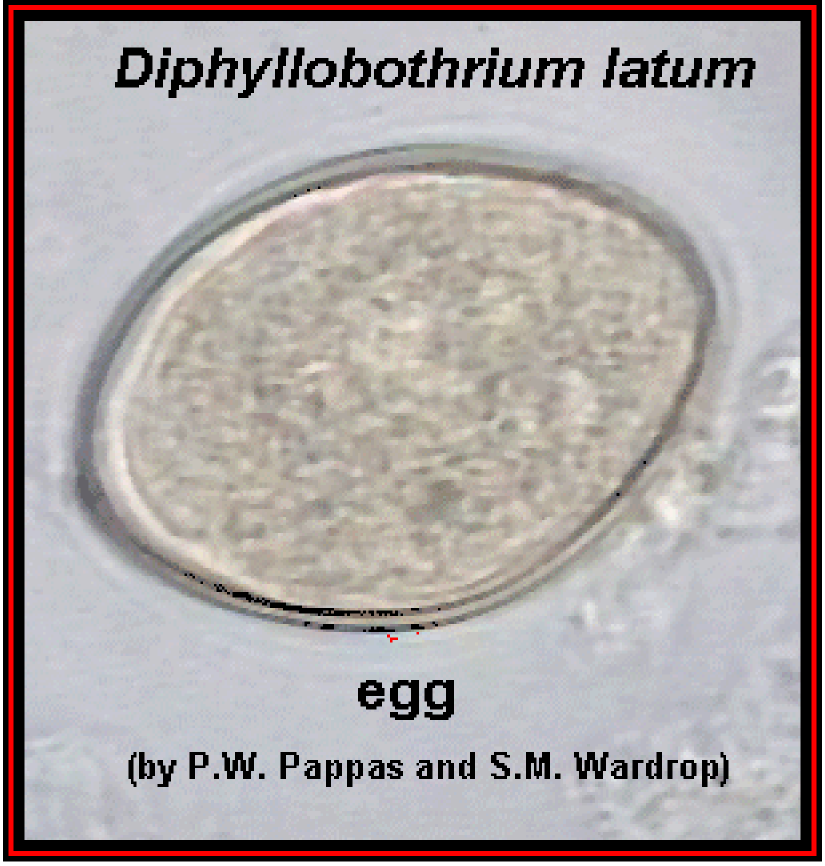
Many "fish eating" vertebrates can serve as the definitive host for *Diphyllobothrium latum* (the broadfish tapeworm), including humans, dogs, foxes, cats, mink, bears, and seals. The adult tapeworm lives in the host's small intestine, and in humans the tapeworm can reach a length of 10 meters (>30 feet) and produce over a million eggs a day!

The life cycle of *D. latum* involves two intermediate hosts. The first intermediate host is a copepod, the second intermediate host is a fish, often pike or salmon, and the definitive host is infected by eating raw or undercooked fish (view diagram of the life-cycle). In humans the tapeworm is more prevalent in areas where humans eats lots of fish; this includes Scandinavia and areas bordering the Great Lakes in the US. Dogs and cats are often infected when they are fed the offal remaining after cleaning fish.

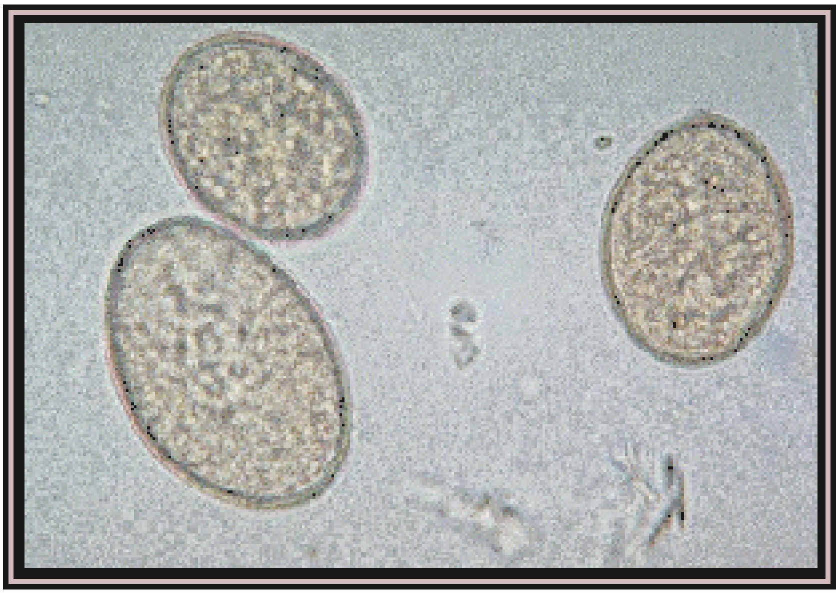
Occasionally, humans are infected with the plerocercoid stage of of cestodes. Such infections are refereed to sparganosis.

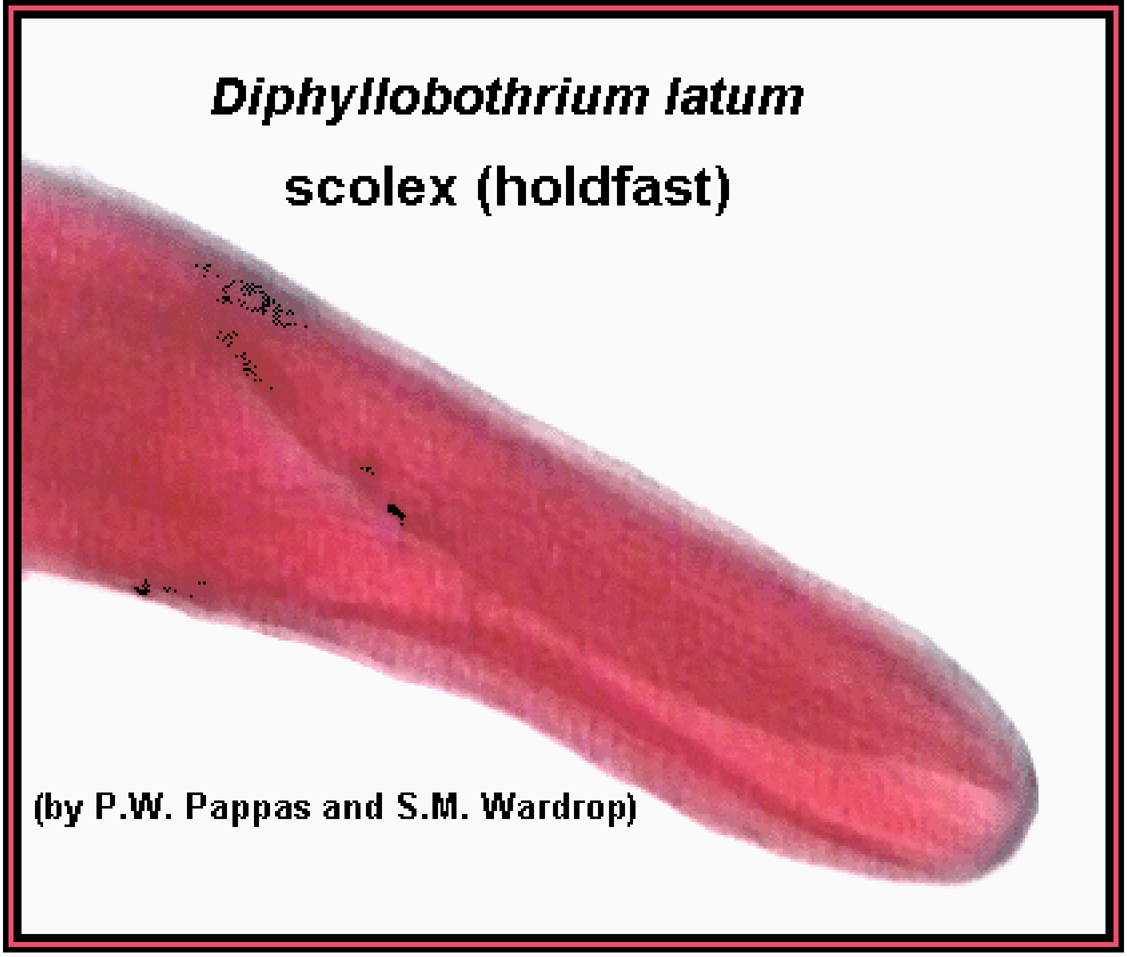


Diphyllobothrium latum egg. The egg measures approximately 50 x 75 µm, has an operculum and an abopercular "bump."

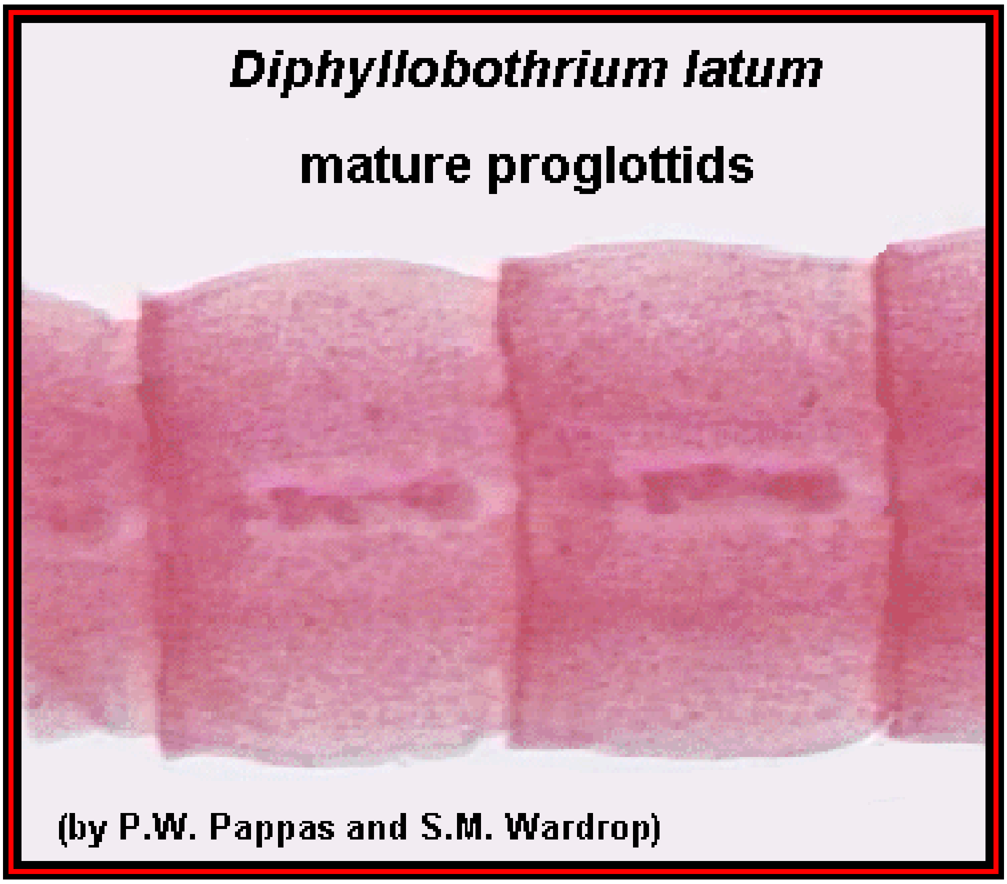


Diphyllobothrium latum egg.


Yet another image of *D. latum* eggs; the "bump" can be seen clearly on one of the eggs. (Original image from Oklahoma State University, College of Veterinary Medicine.)



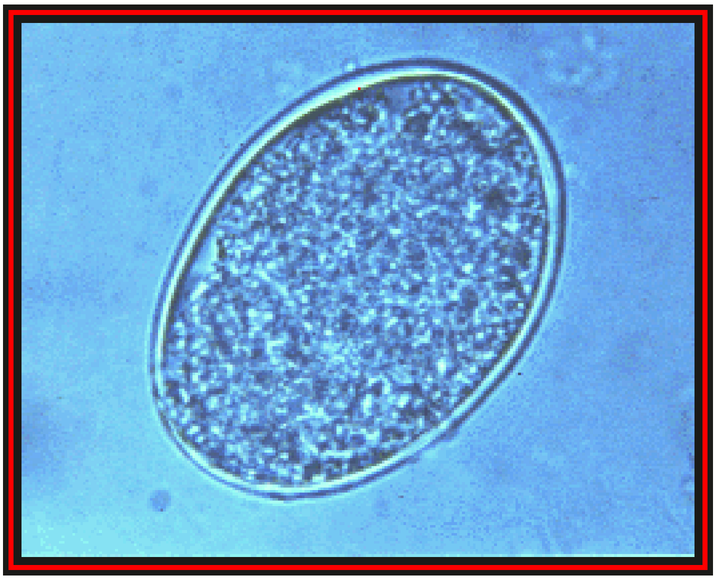
Scolex (holdfast) of *Diphyllobothrium latum*. The scolex is characteristic of pseudophyllidean tapeworms in that it has grooves rather than muscular suckers and hooks; compare with the scolex of *Taenia*. The scolex is less than 1 mm in width.



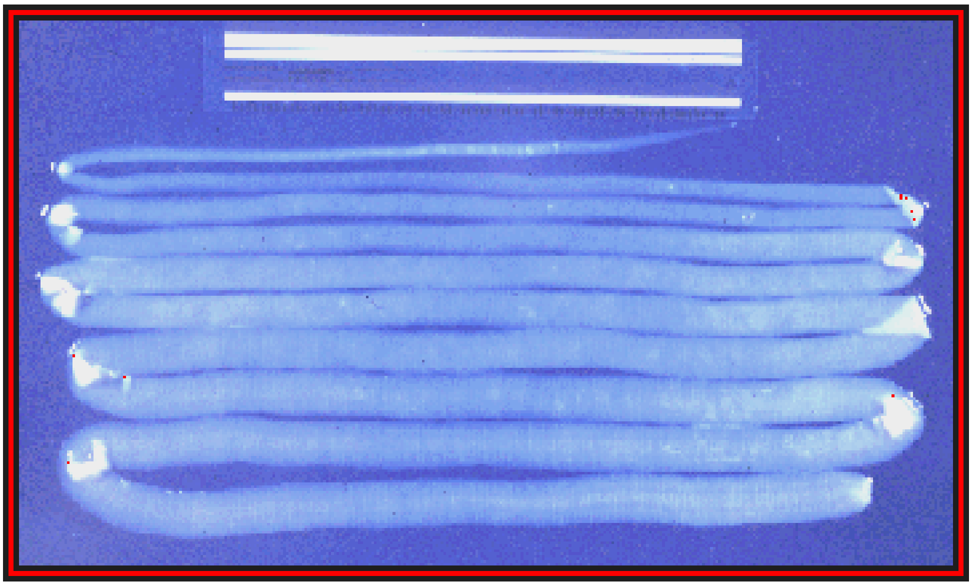
Diphyllobothrium latum proglottids, stained whole mount. Each proglottid measures approximately 2 mm in length. The proglottids are characteristic of pseudophyllidean tapeworms in that the genital pores are medial rather than lateral, and there is a uterine pore; compare with the proglottids of *Taenia*. Click here to view another image in which some of the internal organs are labeled.

Diplogonoporus grandis

Diplogonoporus grandis is a parasite of marine mammals, but about 200 infections in humans have been reported in Japan. Raw or undercooked fish is probably the source of human infections with this cestode. The figures for this species came from "Parasite of the Month" for April, 1996.



An egg of *Diplogonoporus grandis*. The measurements of the egg were not provided, but they average about 65 µm in length.



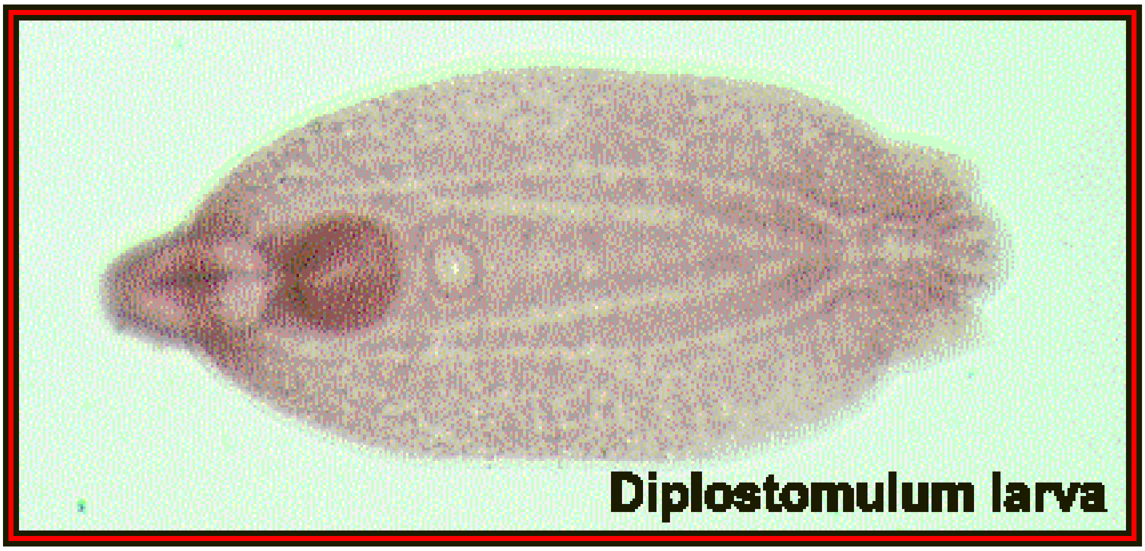
A single specimen of *Diplogonoporus grandis* passed in the stools of an infected human after anthelmintic treatment. The entire specimen measured 273 cm (over 9 feet).

Scanning electron micrograph of the scolex of *Diplogonoporus grandis*. The scolex is typical of pseudophyllidean cestodes.

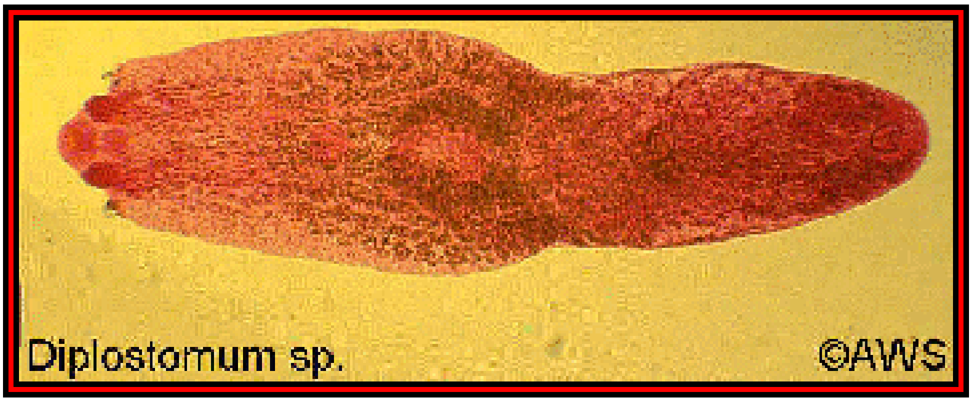
Graphic Images of Parasites

Diplostomulum sp.

Adults of most species in this genus are found in the guts of birds. Eggs are passed in the bird's feces, and snails serve as the first intermediate host. The second intermediate host (most often a fish) is infected by the cercariae, and the resulting stage is called a "diplostomulum larva" (a metacercaria). The avian definitive host is infected when it eats an infected second intermediate host.



A diplostomulum larva (metacercaria) from the eye of *Ictalurus* sp.



An adult *Diplostomulum*. The expanded forebody (anterior end) is at the left of the image. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Graphic Images of Parasites

Dipylidium caninum

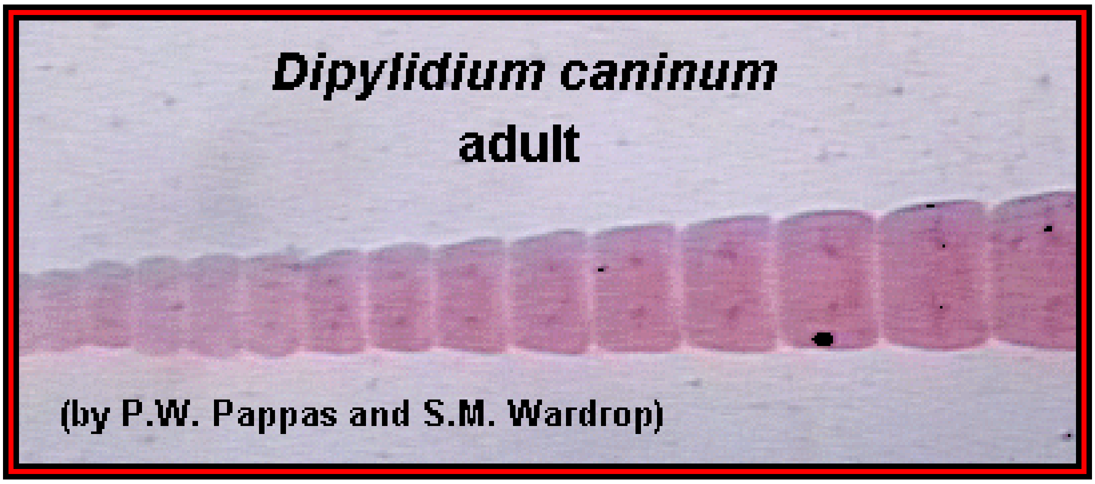
(cucumber tapeworm)

The life cycle of *Dipylidium caninum*, the "cucumber tapeworm," involves dogs or cats (humans rarely) as the definitive host and fleas or lice as the intermediate host. The perianal region of the dog or cat becomes contaminated with eggs when the eggs are passed in the feces, and the flea or louse ingests the eggs. The dog or cat (or human) is infected when they ingest a flea or louse infected with the metacestode state (cysticercoid) (view a diagram of the life cycle). Hence the importance of controlling fleas on your pet!

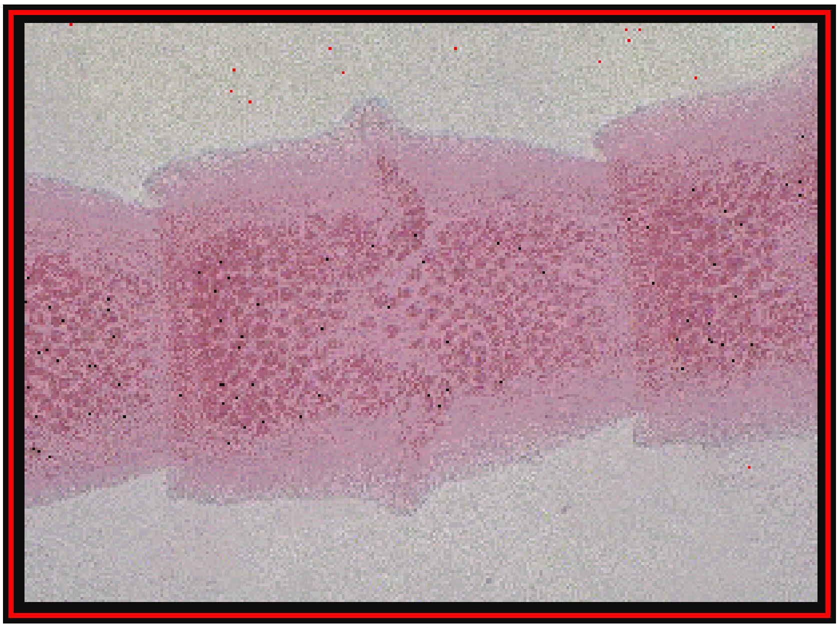
The feces of an infected dog or cat (or human) may contain proglottids (often referred to incorrectly as "segments") that are shed from the tapeworm, and these have a characteristic size and shape (more like rice grains than cucumbers). Diagnosis of this species depends on finding proglottids or "egg packets" (see below) in the feces. (The proglottids of the other common tapeworm of dogs, *Taenia pisiformis*, are much larger and rectangular in shape.)

The eggs of *Dipylidium caninum* are typically passed in the feces in "packets" containing about a dozen eggs. Each egg measures approximately 45 µm in diameter. (Original image from Oklahoma State University, College of Veterinary Medicine.)

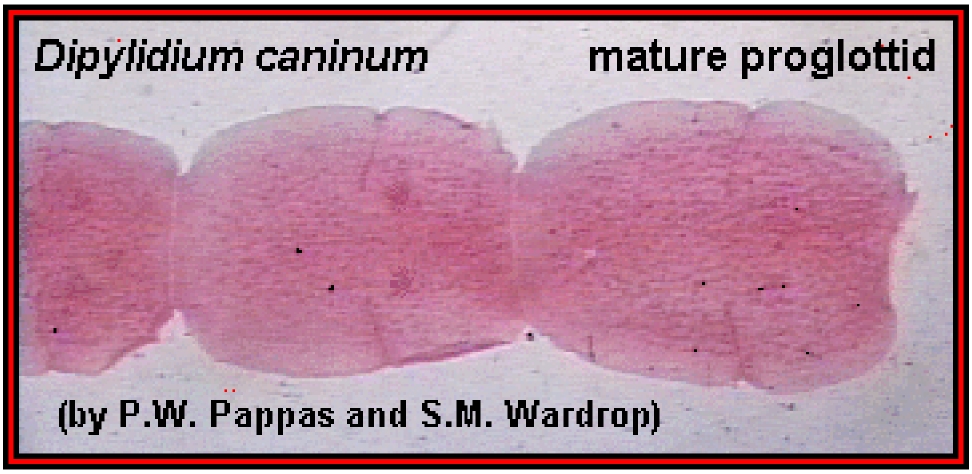
Another example of an egg "packet" of *Dipylidium caninum*. (Original image from the Taipei Medical College Parasitology web site, and modified for use.)



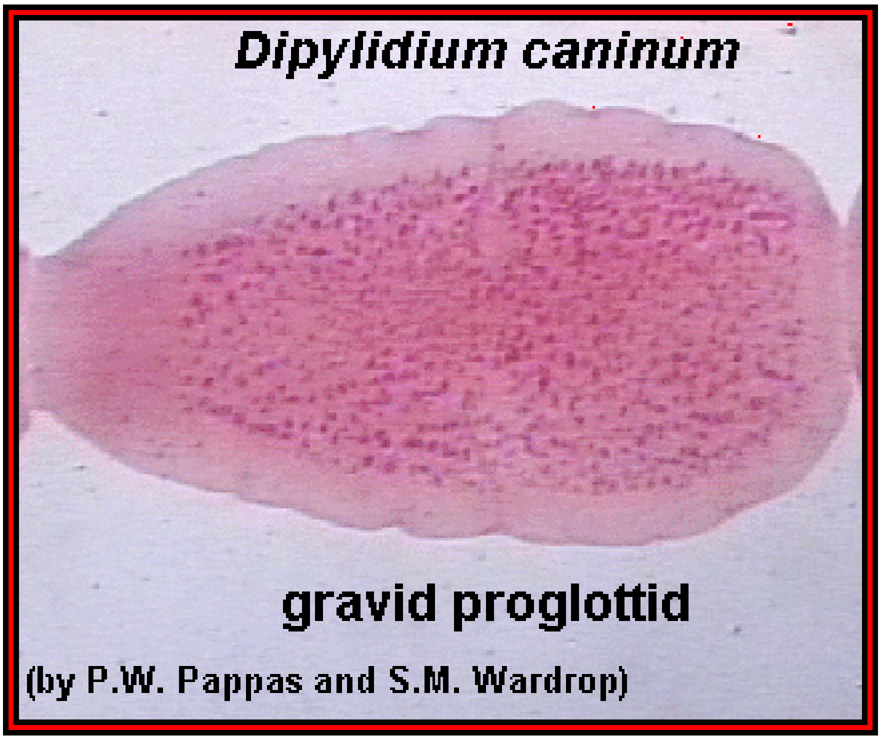
Immature proglottids of *Dipylidium caninum*.



Mature proglottids of *Dipylidium caninum*. The double set of female reproductive organs in each proglottid can be seen. (Original image from Oklahoma State University, College of Veterinary Medicine.)



Mature proglottids of *Dipylidium caninum*. The double set of female reproductive organs can be seen.



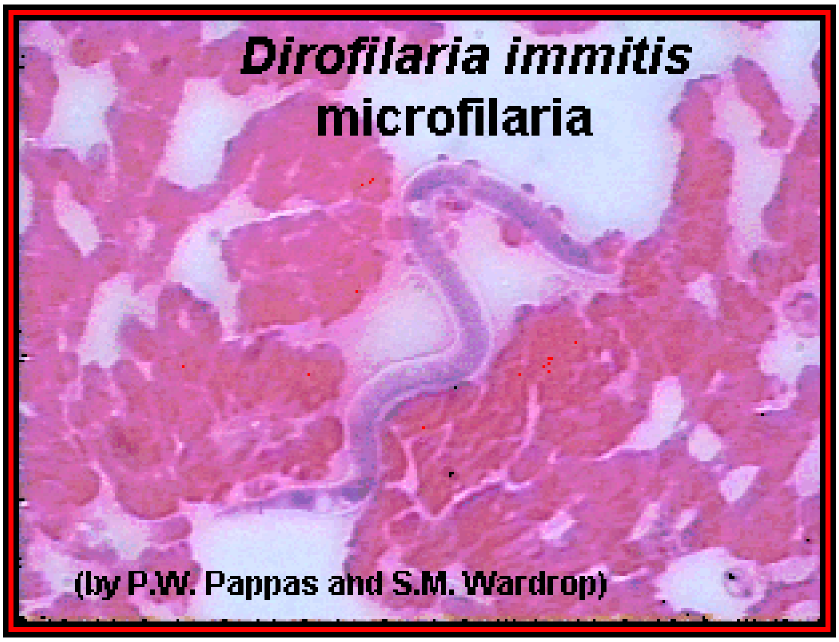
Gravid proglottid of *Dipylidium caninum*. Note the characteristic shape of the proglottid, and that the proglottid is full of egg "packets."

Proglottids of *Dipylidium caninum* compared to a paper match. These are often passed intact in the feces of an infected dog. When the proglottids dry, their appearance is similar to grains of rice. (Original image from F. Rochette, 1999, *Dog Parasites and Their Control*, Janssen Animal Health, B.V.B.A. and used with permission.)

Dirofilaria immitis
(canine or dog heartworm)

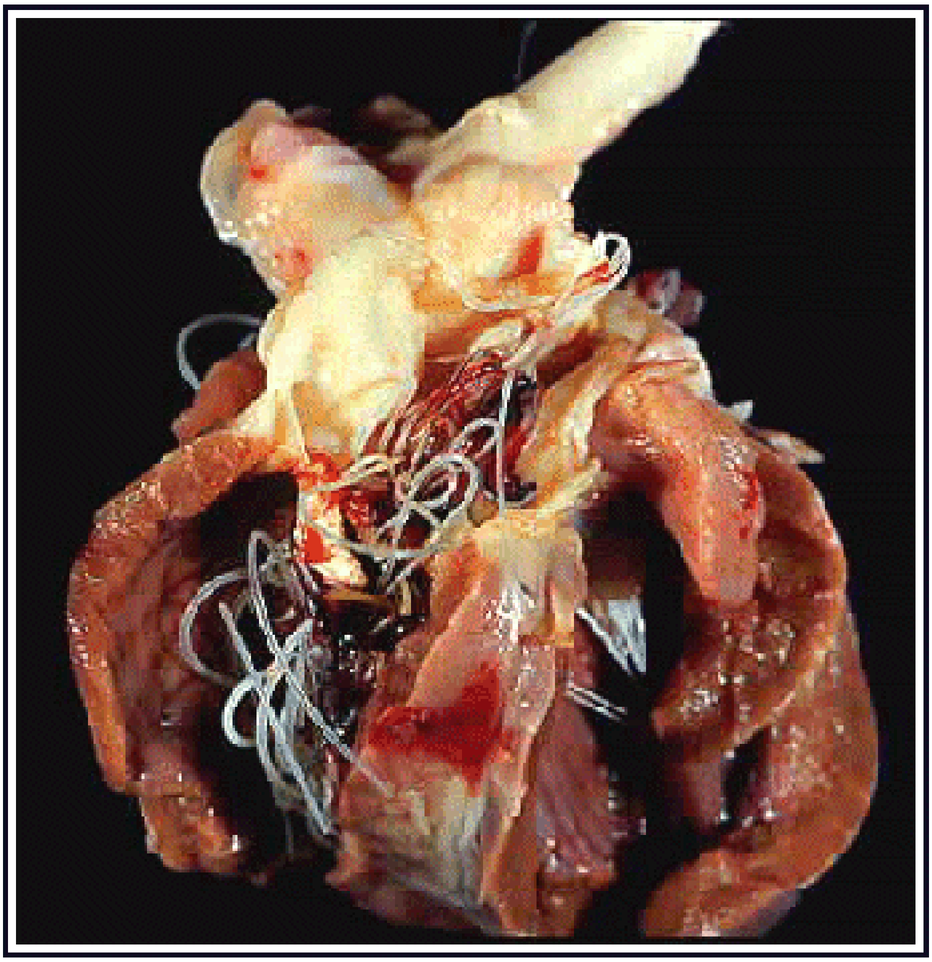
The canine heartworm, *Dirofilaria immitis*, is a common parasite of dogs in many parts of the world (click here to view geographic distribution); it occurs in many other animals, including cats, but it infects humans only rarely. The adult worms are quite large, measuring up to 10 inches long, and they typically live in the dog's pulmonary artery and "right" heart. The female worms produce microfilariae that are found in the dog's blood; demonstration of microfilariae in blood is the primary method of diagnosis (see below). The microfilariae are ingested by a mosquito when it feeds, the microfilariae mature into infective juveniles in the vector, and the infection is transmitted to a new host when the mosquito feeds (view diagram of the life cycle). Many species of mosquitoes will serve as vectors of this species.

This species can cause significant pathology in an infected host. Inflammation and thickening of the heart result in symptoms such as respiratory insufficiency, chronic cough, and vomiting, and the disease can be fatal. A number of effective chemoprophylactic agents are available for this species, and these should be used by pet owners.

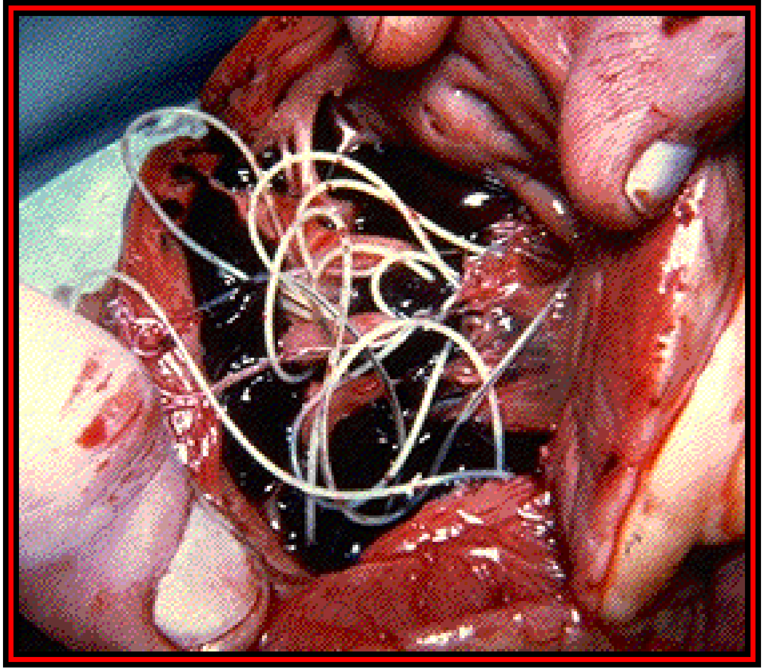


A microfilaria of *Dirofilaria immitis* in a smear of dog blood.

Another example of a *D. immitis* microfilaria. (Original image from Oklahoma State University, College of Veterinary Medicine.)



Dirofilaria immitis adults in the right ventricle of a dog's heart (post-mortem). (Original image from "Companion Animal Surgery.")



Adults of *Dirofilaria immitis* recovered from a dog's heart.

Dracunculus medinensis

(guinea worm, fiery serpent)

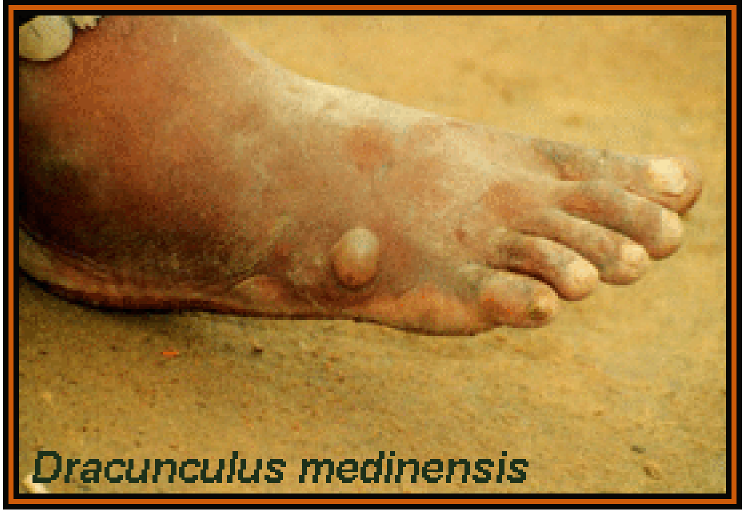
Dracunculus medinensis causes the disease known as dracunculiasis, and the parasite is often referred to as the guinea worm or fiery serpent. This parasite and the disease that it causes have been mentioned in the ancient writings of Greek, Roman, and Arabian scholars. Some authorities believe that the "fiery serpents" that plagued the Israelites were, in fact, *Dracunculus*, while others state that the "serpents" depicted in caducei (various medical symbols) are guinea worms. Although these interpretations remain open to conjecture, it is clear that this parasite and its association with humans have a rich history.

This parasite has a wide geographic distribution, being found throughout much of Asia, the Middle East, Arabia, and northern and equatorial Africa. A similar parasite is found in a number of carnivores and omnivores in North America, but it does not infect humans. This parasite is often referred to as *Dracunculus insignis*, although it may represent a non-human strain of *D. medinensis*.

The life cycle of *D. medinensis* is unusual in many respects. The female worms (which can measure up to 1 meter in length, but are only about 2 mm in diameter) are found in (or just under) the skin of the human host, most often in the legs, ankles, or feet. As the female becomes gravid, her body fills with developing embryos. Eventually, the female's body wall ruptures, and the juvenile worms are released into the human's skin. This causes an intense allergic reaction, extreme discomfort (hence the name, the fiery serpent), and finally a papule forms on the skin. The papule eventually ulcerates (breaks open), exposing the female worm and providing a means of escape for the juvenile worms. As one might expect, humans infected with this parasite often seek out water to alleviate the symptoms of the allergic reaction and to wash the ulcer, and the juvenile worms are liberated into the water. The juveniles are eaten by an intermediate host, a copepod, and humans are infected when they drink water containing infected copepods. Once in the human, the juvenile worms migrate from the intestinal tract, through the abdominal cavity, and into the subcutaneous connective tissues. At this point the females are fertilized by the males, and the males die. The females then migrate to the skin, reach sexual maturity, and produce juveniles. In the human host, complete development of the parasite requires about one year. Click here to view the complete life cycle.

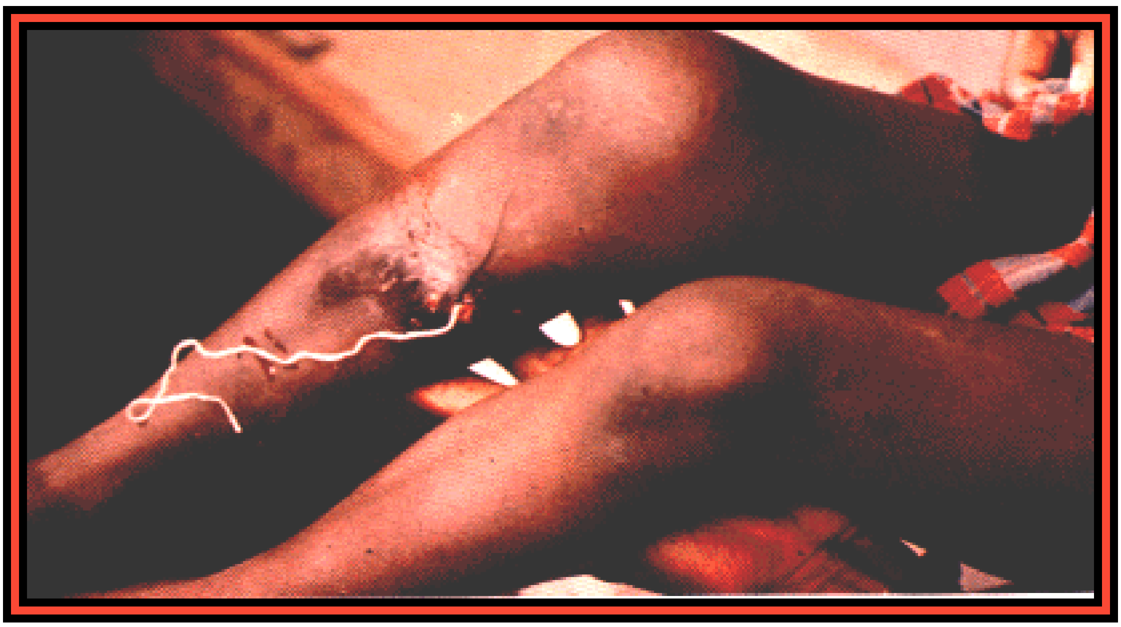
Serious complications can result from from dracunculiasis. The sores produced by the female worms can be infected with bacteria, resulting in abscesses in some instances. Some worms may not find their way to the skin and become encapsulated in the tissues, and in those instances where worms are found near joints, chronic arthritis results. There is no immunity to infection, so humans living in areas with endemic dracunculiasis are reinfected continually, and this can result in physically disabling disease.

Several drugs are used to treat dracunculiasis, but most infections are treated by simply removing the female worm once the blister breaks open and she is visible. Typically, the female worm is attached to a small stick and removed by slowly winding the worm on to the stick. Although this is an effective treatment, it does not prevent much of the damage caused by the worms nor reinfection.



A blister on the foot caused by *Dracunculus medinensis*. (Original image contributed by Global 2000/The Carter Center, Atlanta, Georgia, and copied with permission from [DPDx [Identification and Diagnosis of Parasites of Public Health Concern].])

After rupture, the worm can be seen in the center of the blister. Such blisters are often infected secondarily. At this point the worm can be attached to a stick and removed. (Original image contributed by Global 2000/The Carter Center, Atlanta, Georgia, and copied with permission from [DPDx [Identification and Diagnosis of Parasites of Public Health Concern].])



A large specimen of *Dracunculus medinensis* exiting the leg. (Original image from [The Filarial Genome Network].)

Echinococcus granulosus

(hydatid disease or hydatidosis)

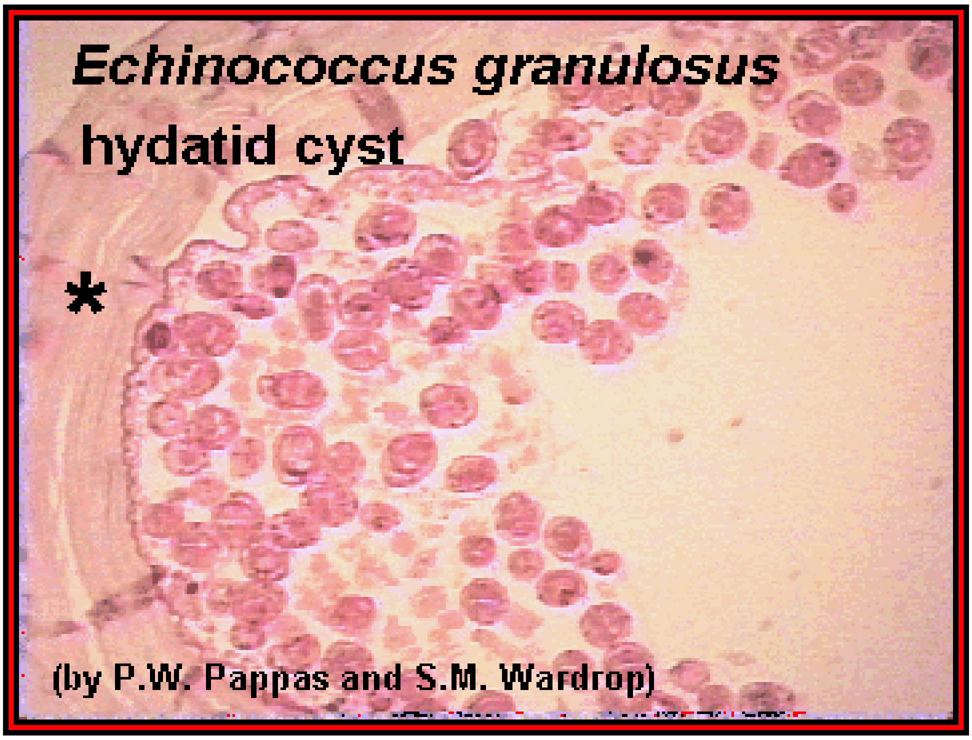
The life cycle of *Echinococcus granulosus* includes dogs (and other canines) as the definitive host, and a variety of species of warm blooded vertebrates (sheep, cattle, goats, and humans) as the intermediate host. The adult worms are very small, usually consisting of only three proglottids (total length = 3-6 mm), and they live in the dog's small intestine. Eggs are liberated in the host's feces, and when these eggs are ingested by the intermediate host they hatch in the host's small intestine. The larvae in the eggs penetrate the gut wall and enter the circulatory system. The larvae can be distributed throughout the intermediate host's body (although most end up in the liver) and grow into a stage called a hydatid cyst (view diagram of the life cycle).

Hydatid cysts have the ability to grow quite large; cysts the size of golf balls are not uncommon, and cysts the size of basketballs are reported on rare occasions. The pathology associated with hydatid disease in the intermediate host depends on the size of the cyst and its location. One or two small cysts in the liver of a host might go unnoticed for years. However, a single large cyst in the liver could prove fatal. Hydatid disease is far more serious when the cysts are found in other locations, particularly the brain (see below).

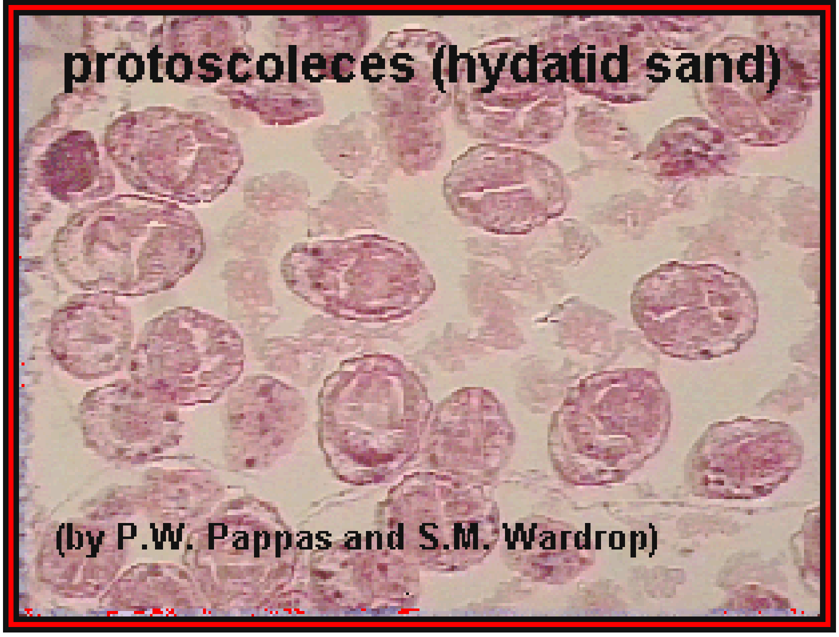
The infection is transmitted to the definitive host when the hydatid cyst is eaten. As one might suspect, this species of parasite is more common in areas of the world where dogs are used to herd sheep (view geographic distribution). Under most circumstances humans are a "dead end" in the life cycle, but hydatid disease in humans remains a serious problem because the disease can cause such serious pathology.

The interior of a hydatid cyst is filled with "protoscolices" (singular = protoscolex), each of which has the ability to grow into an adult worm when ingested by a canine host. A small cyst might contain hundreds of protoscolices; a large cyst might contain tens of thousands! This tremendous reproductive potential poses a problem in the intermediate host (particularly in humans). If a hydatid cyst breaks open, each protoscolex could grow into a new hydatid cyst. How might this happen? A sharp blow to the abdomen might rupture a cyst in the liver. A number of cases have been reported in which cysts have been damaged during routine surgery, allowing the cyst's contents to leak into the patient's abdominal cavity.

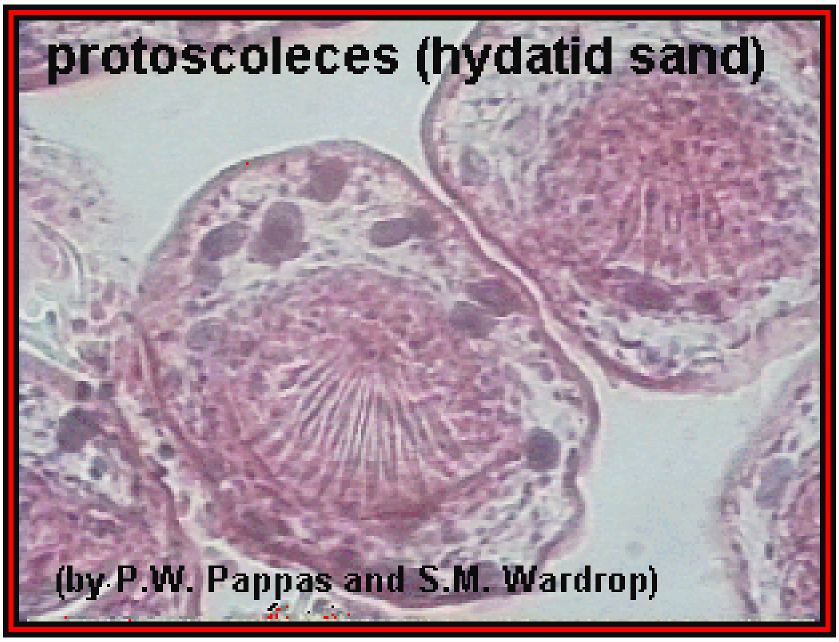
A hydatid cyst (*) in the cranium of a child (the ruler at the top measures 6 inches long, and the child's brain is below the hydatid cyst). This infection resulted in the child's death.



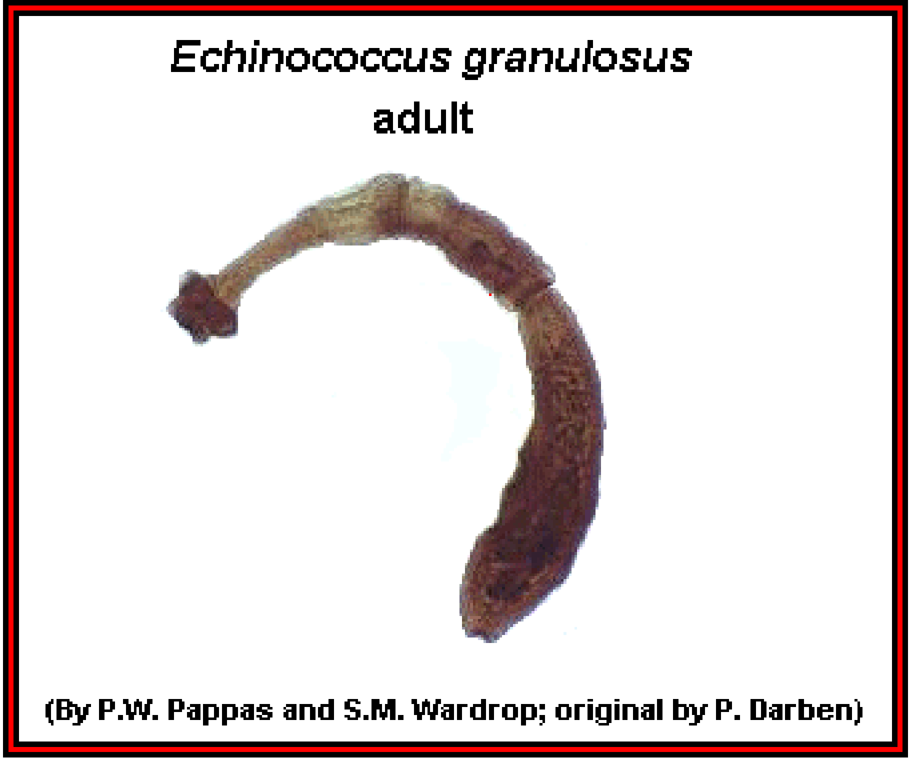
A section of a hydatid cyst at low power. The cyst consists of a thick outer layer (*), several thinner internal layers, and many protoscolices. The protoscolices are often called "hydatid sand."



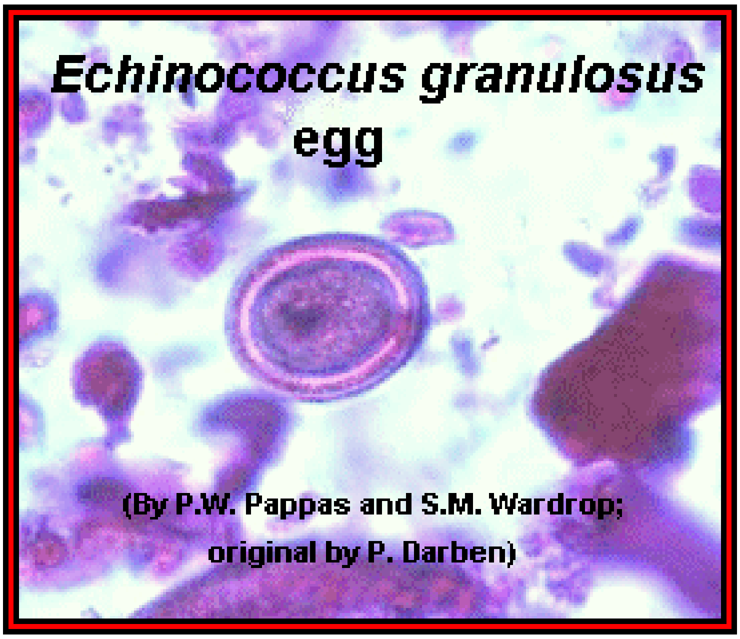
Higher magnification of the protoscolices.



A single protoscolex. Note the "hooks" that will form the hooks associated with the adult worm's armed rostellum.



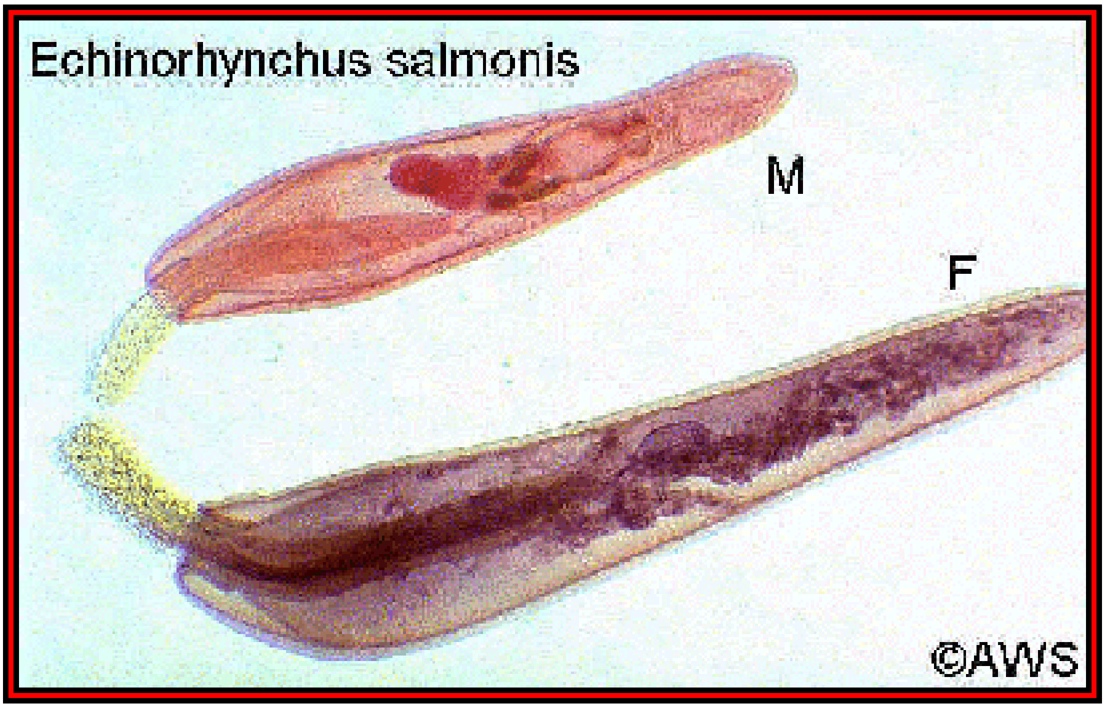
An adult *Echinococcus granulosus*; note that the tapeworm's body (strobila) consists of only three proglottids and measures only about 5 mm in length.



An egg of *Echinococcus granulosus*; these eggs are virtually indistinguishable from other, closely related species of tapeworms such as *Taenia*.

Echinococcus granulosus (the small, white objects) in the small intestine of a dog. Although these tapeworms are quite small, a single dog can be infected with many of them. (Original image from F. Rochette, 1999, *Dog Parasites and Their Control*, Janssen Animal Health, B.V.B.A. and used with permission.)

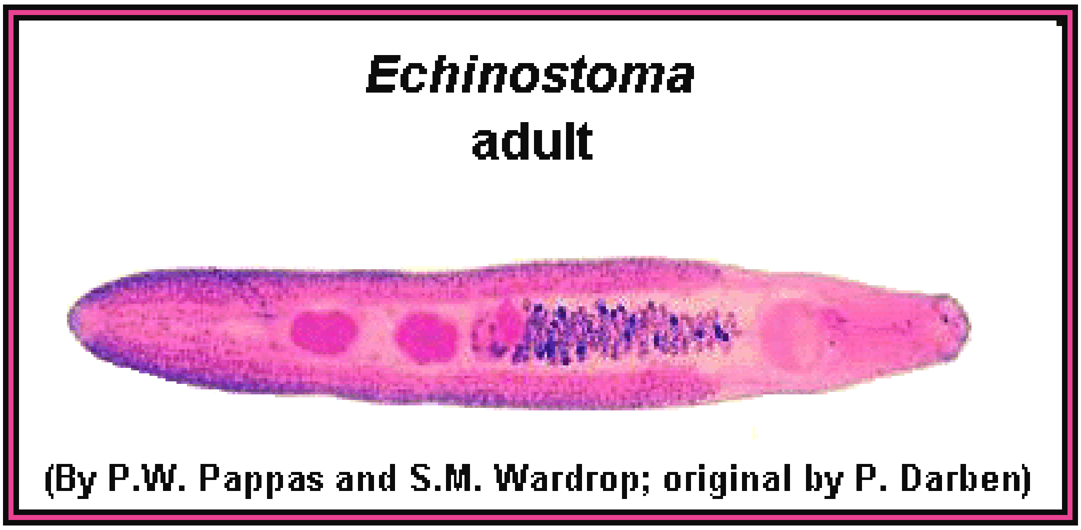
Echinorhynchus sp.



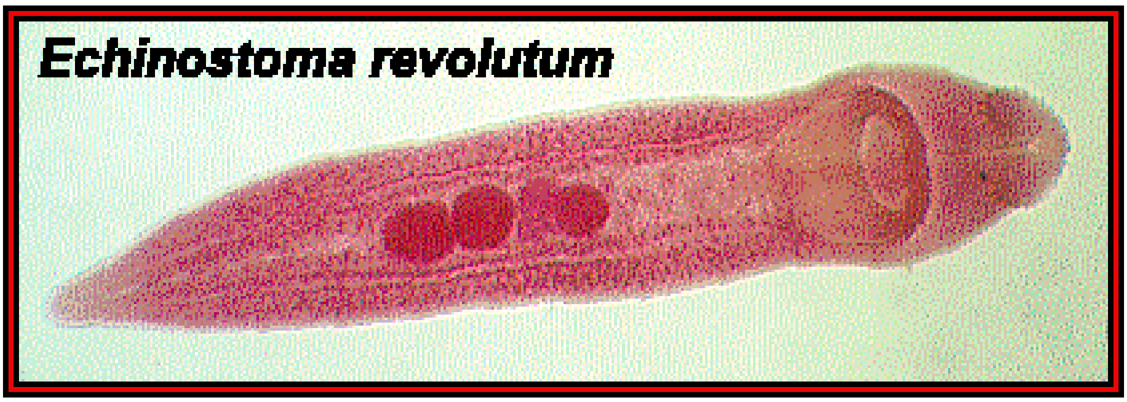
An adult male (M) and female (F) of *Echinorhynchus salmonis*. Note the well developed, armed proboscis at the anterior end of each worm. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Echinostoma sp.

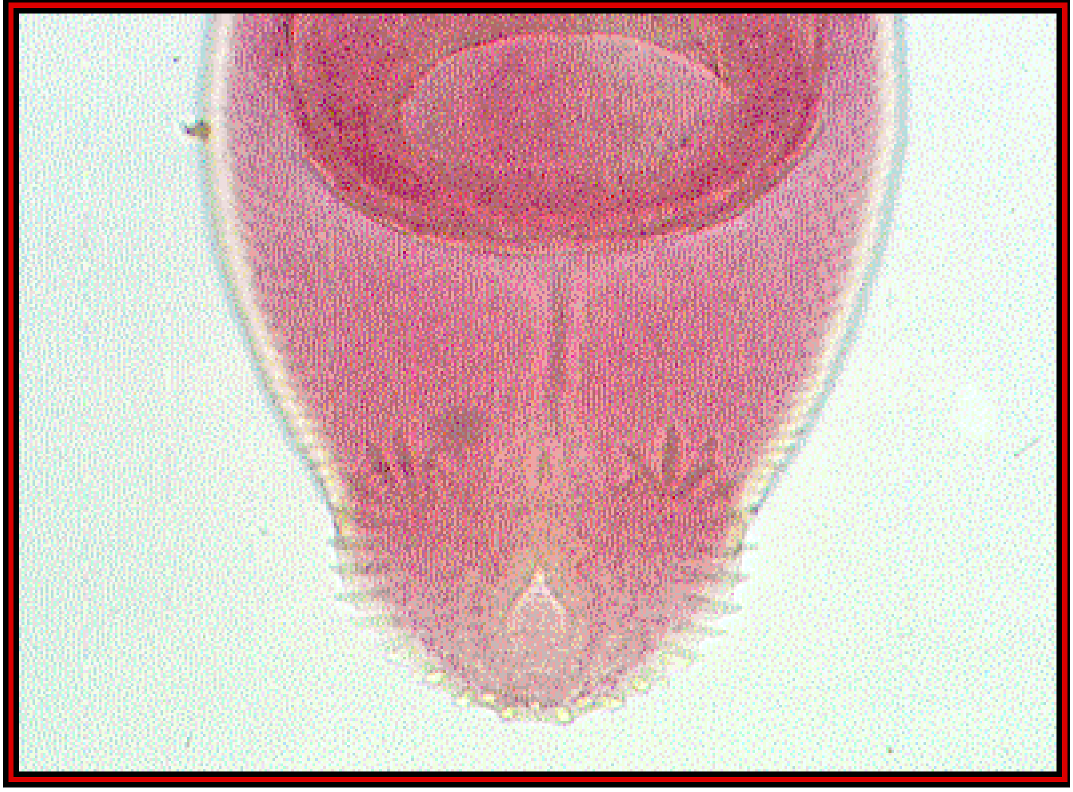
"Echinostomes" are characterized by the presence of a collar of "spines" around their anterior ends. Their external surface, or tegument, is also studded with spines or papillae, but this is not unique to echinostomes (see below). Echinostomes are widely distributed throughout the world and are found in many species of warm blooded vertebrates, and in some parts of the world human infections with echinostomes are common. The number of species in the genus *Echinostoma* remains uncertain; some authors say there are only a dozen or so species, while others say there are "hundreds." The life cycles of echinostomes are typical of digenetic trematodes. The adults (which measure about 1 cm in length) are found in the small intestine of the definitive host, and the first intermediate host is a snail; depending on the "species," the second intermediate host can be a snail, a mollusk (i.e., a clam or mussel), or even a free living flatworm.



Stained whole mount of *Echinostoma* sp. (probably *E. revolutum*). This specimen is about 25 mm in length. (Click here to view a second, labeled image.)



Another stained whole mount of *Echinostoma revolutum*.



A higher magnification of the anterior end of an adult echinostome showing the characteristic papillae.

Scanning electron micrograph of an adult echinostome. (Used with permission of Dr.Bernard Fried.)

Echinostoma cohensi recovered from a herring gull.

Graphic Images of Parasites

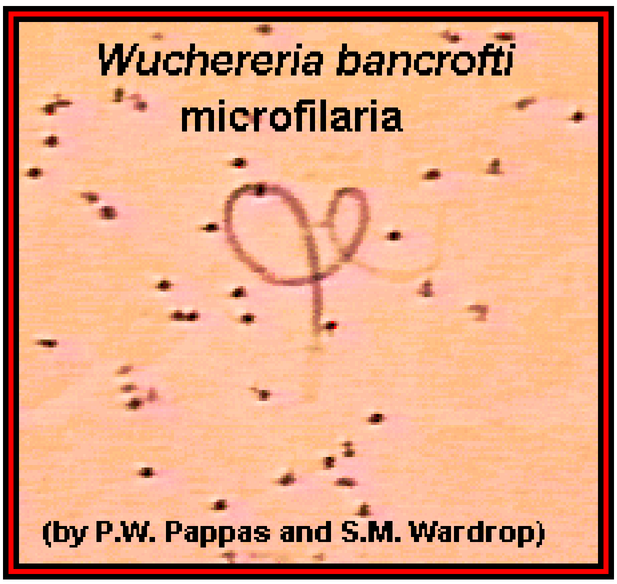
Wuchereria bancrofti

(bancroftian filariasis)

Most people are probably more familiar with this disease known by another name, "elephantiasis." The adults of this parasite live in the lymph nodes of humans, and the female worms produce microfilariae (advanced embryos) that are found in the blood. The microfilariae are ingested by a mosquito when it feeds, and in the mosquito the microfilariae transform into infective larvae. When the mosquito feeds again on a human, the infection is transmitted via the larvae. The larvae migrate to the lymph nodes, reach sexual maturity, and the life cycle is complete. Several genera of mosquitoes will transmit this parasite, including *Anopheles*, which is also a vector for malaria (*Plasmodium* spp.) (view a diagram of the life cycle). Like other filarial infections, bancroftian filariasis is diagnosed most often by demonstrating microfilariae in a blood smear.

Bancroftian filariasis, and a similar disease caused by *Brugia malayi*, are distributed throughout much of central Africa and southern and S.E. Asia (view geographic distribution of lymphatic filariasis). Repeated infections with bancroftian filariasis, as would happen in areas of endemic disease, can result in blockage of the lymph nodes and ducts. This results in the accumulation of lymph and swelling of the tissues. The adults tend to prefer the lymph nodes that drain the lower abdominal cavity and legs, so "elephantiasis" is often marked by gross disfigurations of the genitals and legs. Any introductory level parasitology textbook will contain pictures of humans infected with "elephantiasis." Viewing such pictures, especially those showing gross disfiguration of the genitals, is better left to those with a "strong stomach." (Click here to view images of humans suffering from elephantiasis ---- **WARNING**, these images are quite graphic.)

Elephantiasis is not "Elephant Man disease." For many years it was assumed that Joseph Merrick, known as the Elephant Man, suffered from neurofibromatosis, and for this reason neurofibromatosis is often called "Elephant Man disease." Neurofibromatosis is not caused by a parasite; it is a genetic disease. There is now speculation that Merrick actually suffered from a much rarer condition known as Proteus syndrome.



A microfilaria of *Wuchereria bancrofti* as it would appear in a blood smear; approximate size = 200 µm in length.

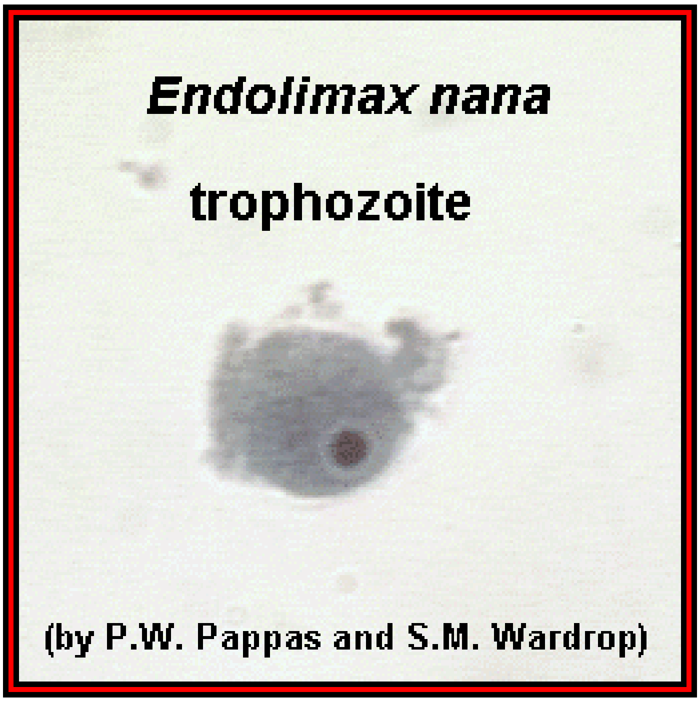
Another microfilaria of *Wuchereria bancrofti* as it would appear in a blood smear.

Endolimax nana

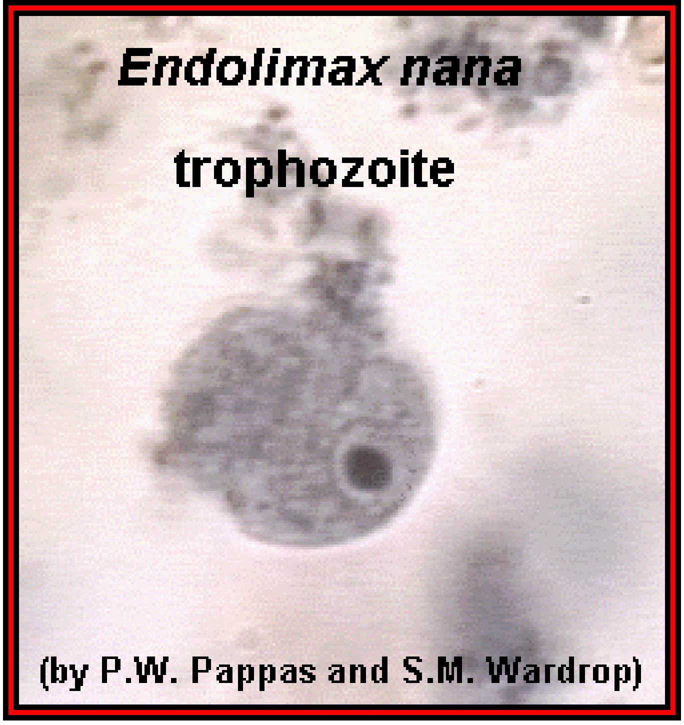
(a commensal)

The life cycle of *Endolimax nana* involves trophozoites that live in the host's large intestine and cysts that are passed in the host's feces. Humans are infected by ingesting cysts, most often in food or water contaminated with human fecal material. This species is considered to be a commensal (non-pathogenic). Nevertheless, it is important to differentiate this species from the pathogenic *Entamoeba histolytica* since it would be inappropriate to treat a person if they were not infected with a potential pathogen. The presence of this organism is, however, of concern, since it would indicate that the infected person might be infected with other organisms that are transmitted via human waste.

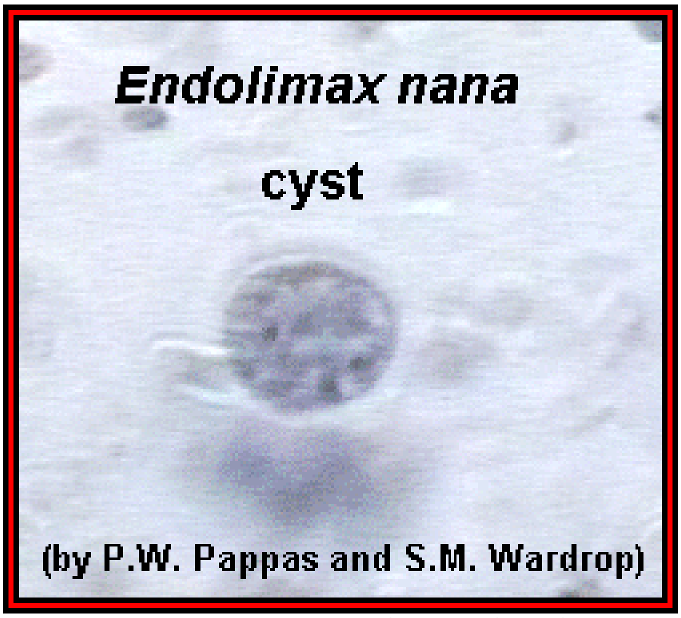
This species can be differentiated from *Entamoeba histolytica* and *Entamoeba coli* based on its much smaller size and appearance of the nucleus (a large endosome with little chromatin on the nuclear membrane).



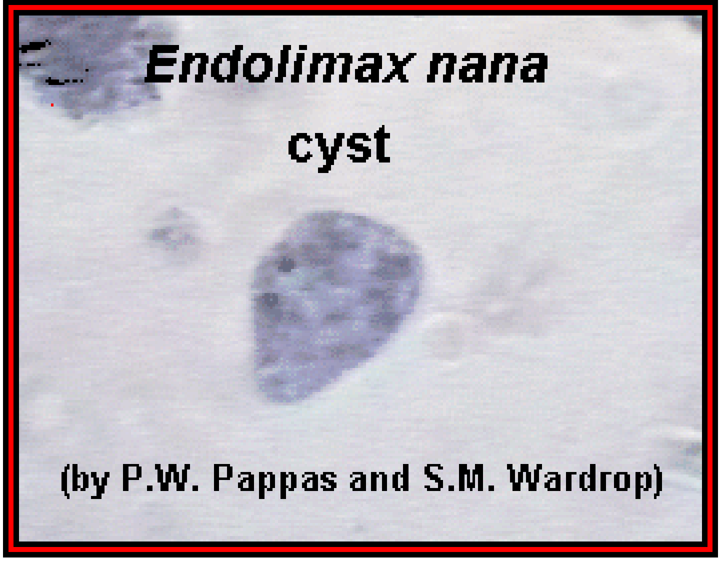
Endolimax nana trophozoite. The single nucleus with its large endosome can be seen. The nuclear membrane can not be seen since there is little chromatin associated with it; approximate size = 12 µm.



Endolimax nana trophozoite; approximate size = 13 µm.



Endolimax nana cyst; approximate size = 10 µm. Endosomes of three of the four nuclei are visible in this plane of focus.



Endolimax nana cyst; approximate size = 10 µm. Endosomes of two of the four nuclei are visible in this plane of focus.

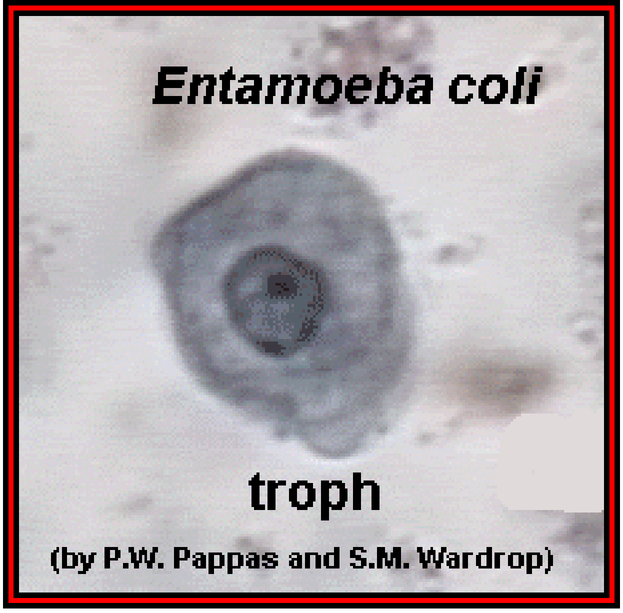
Entamoeba coli

(a commensal)

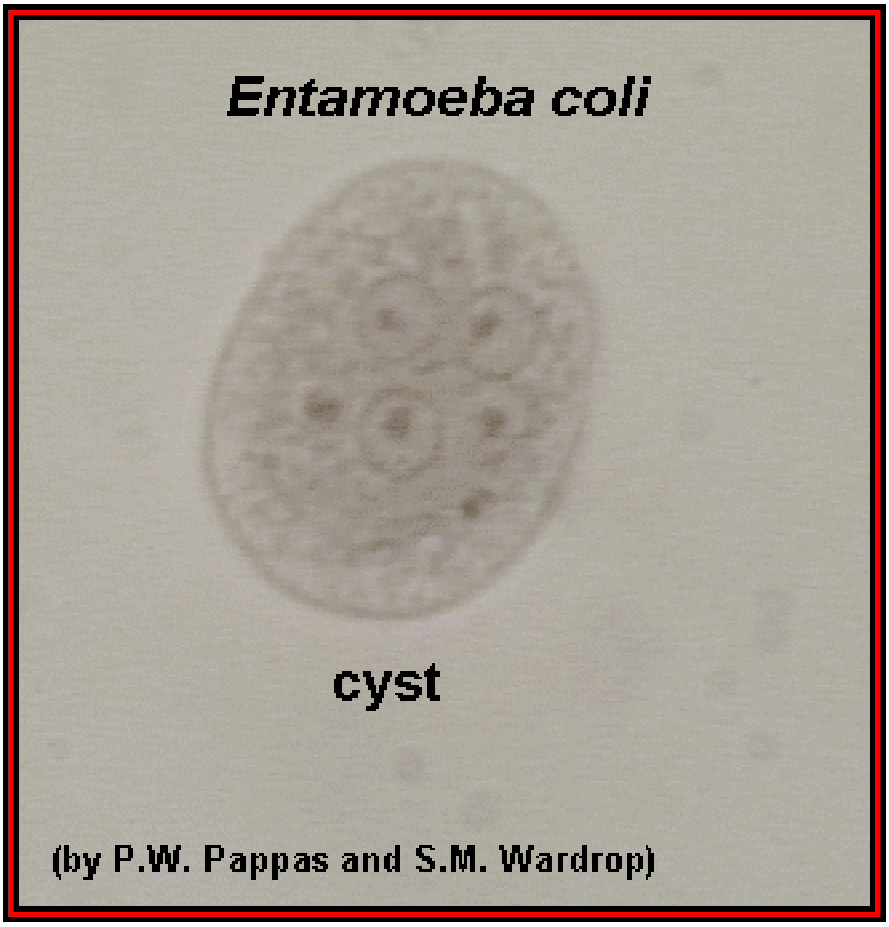
Entamoeba coli is a commensal of the human large intestine, but it looks much like *Entamoeba histolytica* (a potential pathogen). Thus, it is important that the two species be differentiated. Also, the life cycles of the two species are virtually identical, with humans being infected by ingesting food or water contaminated with cysts (human fecal material). If someone is infected with this organism, it means they have been (or are currently being) exposed to human fecal material.

Entamoeba coli is not the *"E. coli"* that humans can get from eating raw or undercooked meat and that has been associated with a number of human fatalities in the past few years. The other *"E. coli"* is a bacterium (prokaryote), *Escherichia coli*

Entamoeba coli trophozoite. The single nucleus with its eccentric endosome and irregular chromatin is visible; approximate size = 20 µm.



Entamoeba coli trophozoite. The single nucleus with its eccentric endosome and irregular chromatin is visible; approximate size = 24 µm.



Entamoeba coli cyst. Four nuclei, and the endosomes of two additional nuclei, are visible in this plane of focus; approximate size = 24 µm.

Pinworms

(*Enterobius vermicularis*, *Oxyuris* spp.)

It is estimated that pinworms infect more than 400,000,000 people throughout the world (10% of humans), and in many areas of the world (e.g., North America and Europe) it is the most common nematode parasite of humans. On a world-wide basis, however, *Ascaris lumbricoides* ranks #1 infecting more than 1,000,000,000 people (25% of humans).

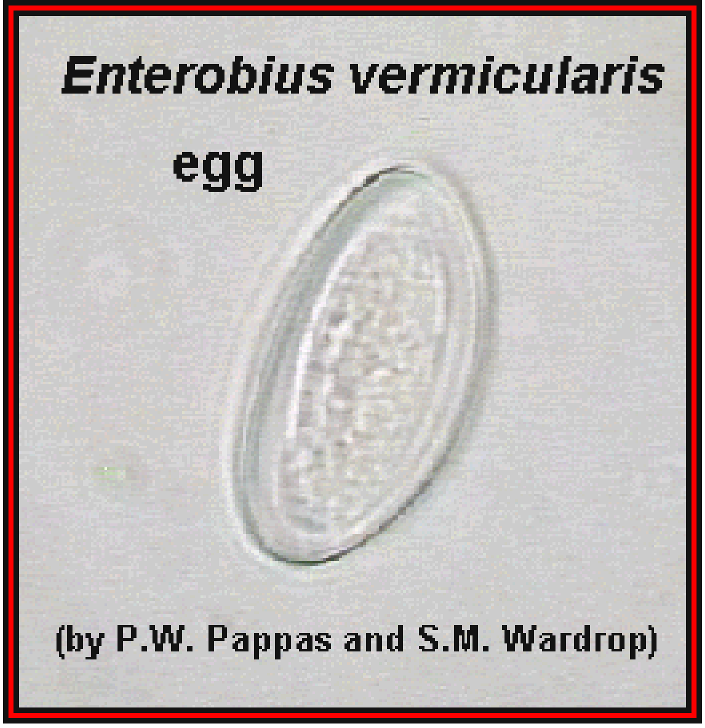
Adult pinworms live in the large intestines; males and females are about 5 mm and 10 mm long, respectively. After copulation the males die. When the female is ready to lay eggs she crawls out of the anus and deposits the eggs on the perianal skin; a single female can produce more than 10,000 eggs. After laying her eggs, the female also dies. At body temperature the eggs develop quickly and are infective (contain 3rd stage juvenile worms) in about six hours. When ingested by another person the eggs hatch in the small intestine, and the juvenile worms grow into adult, sexually mature worms in about a month (view diagram of the life cycle).

Pinworms infections can be asymptomatic or result in mild gastrointestinal upsets. A common symptom associated with pinworm infections is perianal itching. Scratching of the perianal skin to relieve the itching can lead to bacterial infections that result in more itching, etc. This cycle can result in a situation where the infected person becomes very uncomfortable. Children infected with pinworms often undergo behavioral changes, including restlessness, irritability, and insomnia. In women, the adult pinworms can enter the vagina and cause additional irritation.

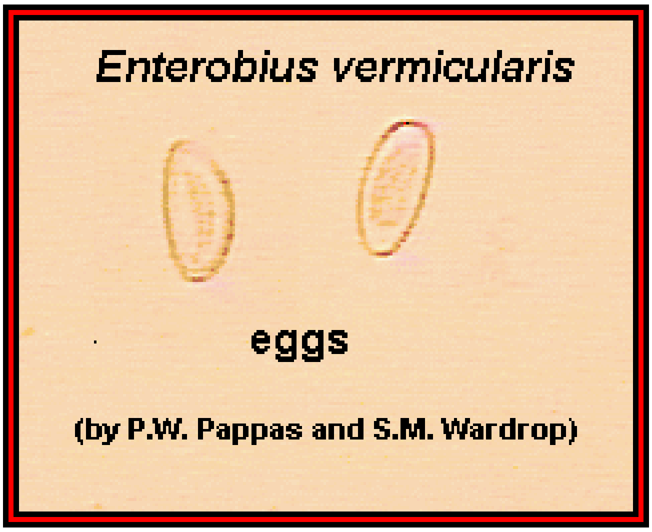
Pinworms are highly contagious! The eggs are infective within a few hours of being laid, and they are deposited directly on the perianal skin. Bed linens, clothing, carpets, etc., can be contaminated with eggs. The infected person's hands will, invariable, be contaminated with eggs, providing a route for reinfection and egg dispersal (even into the classroom). It is for this reason that if one member of a family is infected for pinworms, the whole family is treated.

There is evidence that *Dientamoeba fragilis*, a "protozoan parasite" of humans, is transmitted among humans in the eggs of pinworms. Thus, pinworm and *Dientamoeba* infections may occur simultaneously.

Pinworm infections are detected by finding the eggs or worms on the perianal skin. If the perianal skin is examined using a flashlight the worms can be seen; the literally "glow" under the bright light. (Click here for an image of pinworms on the perianal skin. Warning, this is not a particularly pleasant image.) Because the female pinworms lay their eggs during the early morning hours, it is the child's parent who must examine the perianal skin for the worms. Understandably, finding pinworms on your child's perianal skin is not something a parent soon forgets. Eggs on the perianal skin can be detected by using a piece of cellophane ("Scotch") tape attached to a wooden applicator stick, sticky side out. The tape is then pressed against the perianal skin and later examined for eggs. This is best done as soon as a child awakens, so this responsibility also falls on the child's parents.

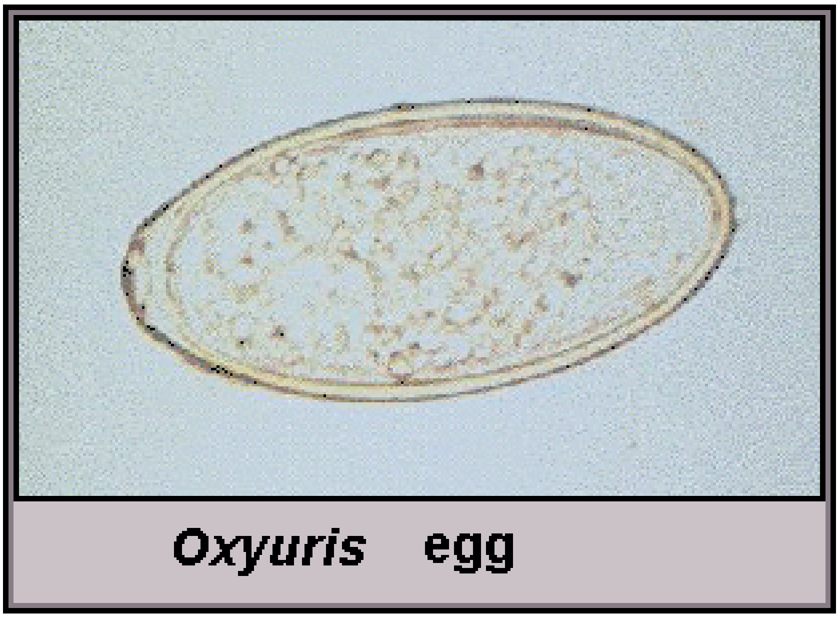


Enterobius vermicularis egg. Note the thin shell and characteristic shape; approximate length = 55 µm.



Enterobius vermicularis eggs.

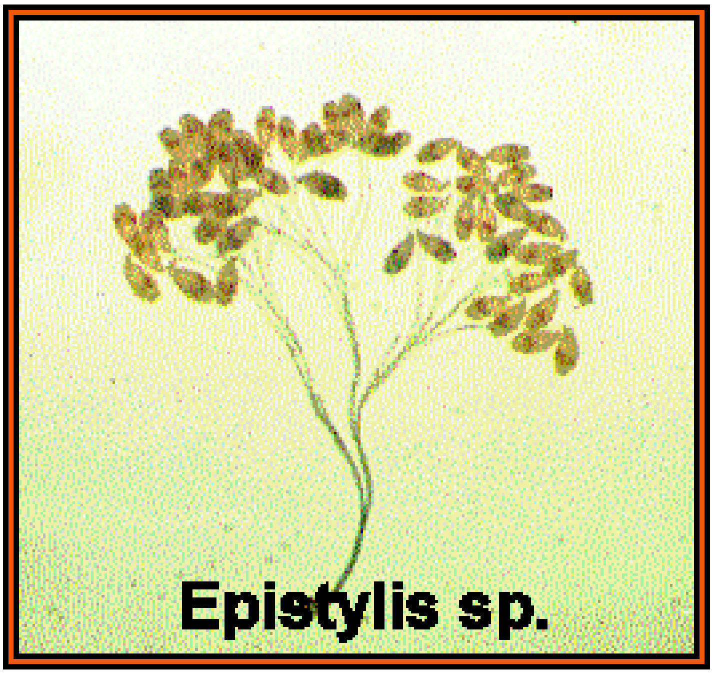
An adult pinworm. Note that the posterior end (on the right) is drawn to a fine point. You can also see the cephalic alae at the anterior end. (Original image from Oklahoma State University, College of Veterinary Medicine.)



An egg of *Oxyuris equi*. This is a cosmopolitan parasite of horses and can cause intense perianal itching. Horses have been known to rub against fence posts and even barbed wire to relieve this itching. (Original image from Oklahoma State University, College of Veterinary Medicine.)

Epistylis sp.

This genus contains several species of colonial ciliates. These species are described by various authors as being "ectosymbiotes" or "obligate ectocommensals" on the surfaces of aquatic invertebrates. Members of this genus can, however, also be found on the surfaces of vertebrates (see Trichodina).



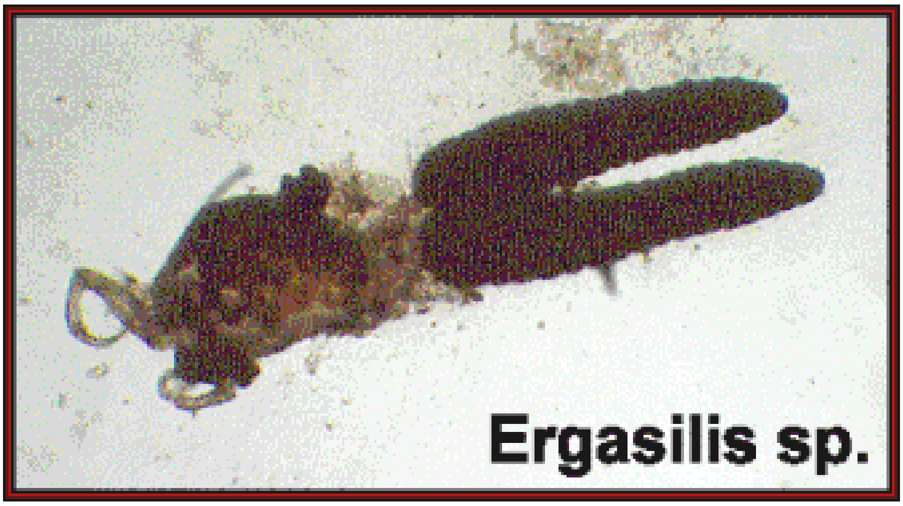
A colony of *Epistylis* sp. The colonies can measure up to 2 mm in height.

A higher magnification of the above image showing the individual organisms forming the colony.

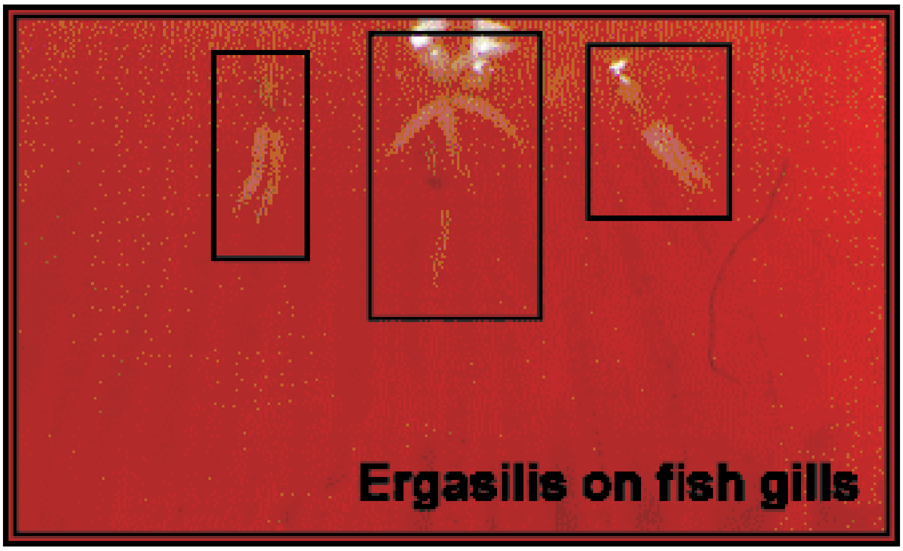
Ergasilus spp.

Members of this genus are common parasites on the gills of freshwater and marine fish. Ergasilids are not as highly modified as *Lernea* spp., and they are easily recognizable as copepods. Several of their anterior appendages are, however, highly modified for attachment purposes.

Heavy infections of ergasilids on the gills of fishes can cause significant pathology, as well as increasing the chances of secondary infections. Under the appropriate conditions, ergasilids can cause considerable mortality.



A female *Ergasilis* removed from the gills of an infected fish.



Several specimens of *Ergasilis* on the gills of a freshwater fish (black rectangles).

Graphic Images of Parasites

Eurytrema pancreaticum

Eurytrema pancreaticum is a parasite of the pancreatic ducts of pigs, cattle, camels, and monkeys; it has been reported once from humans. This species is found in many parts of the Orient and in a few areas of South America. Its life cycle involves a terrestrial snail as the first intermediate host and a grasshopper as the second intermediate host (view diagram of the life cycle).

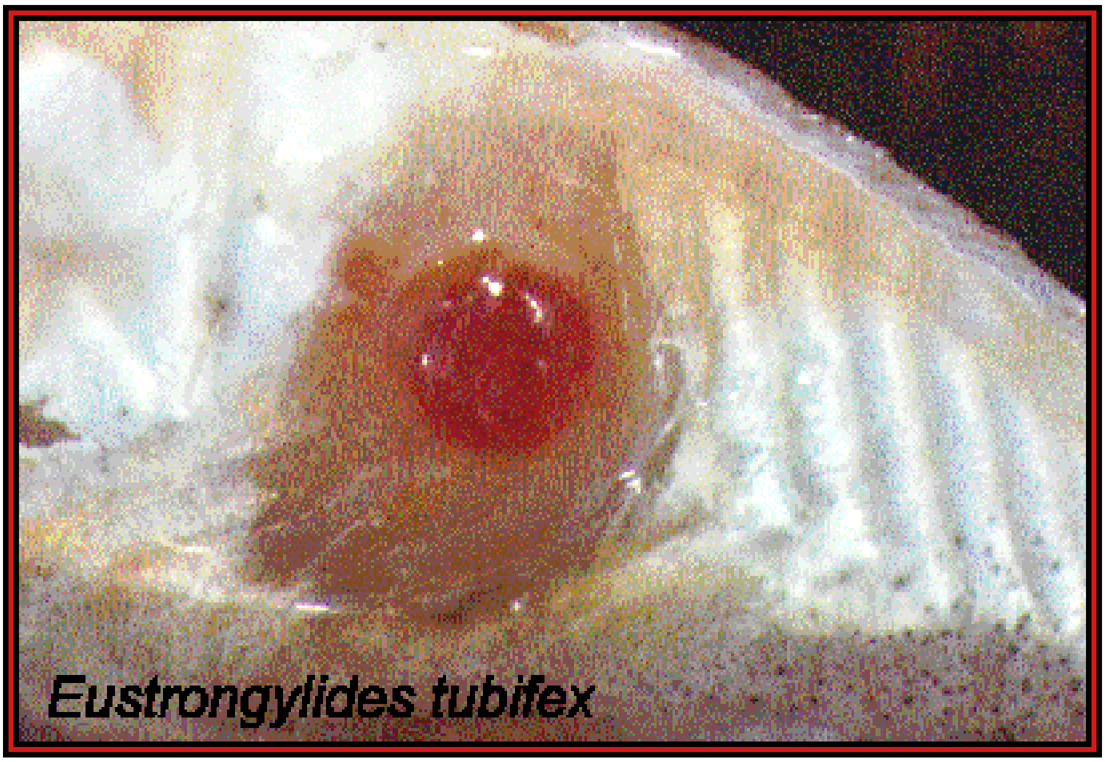
Eurytrema pancreaticum, adult, stained whole mount; approximate size = 11 mm. Click here to view another image in which the morphological features are labeled.

Graphic Images of Parasites

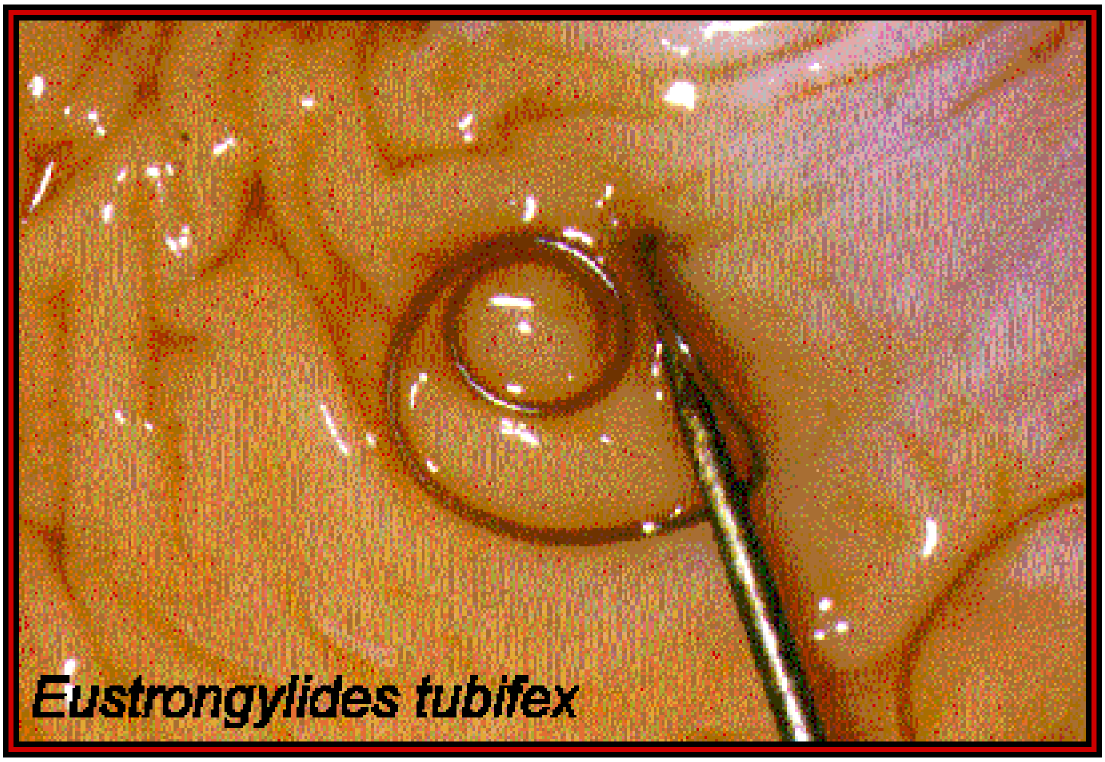
Eustrongylides tubifex

This species is found in the proventriculus of birds and uses a fish as an intermediate host. You can view a diagram of the life-cycle here.

A lesion caused by *Eustrongylides tubifex* in a yellow perch.

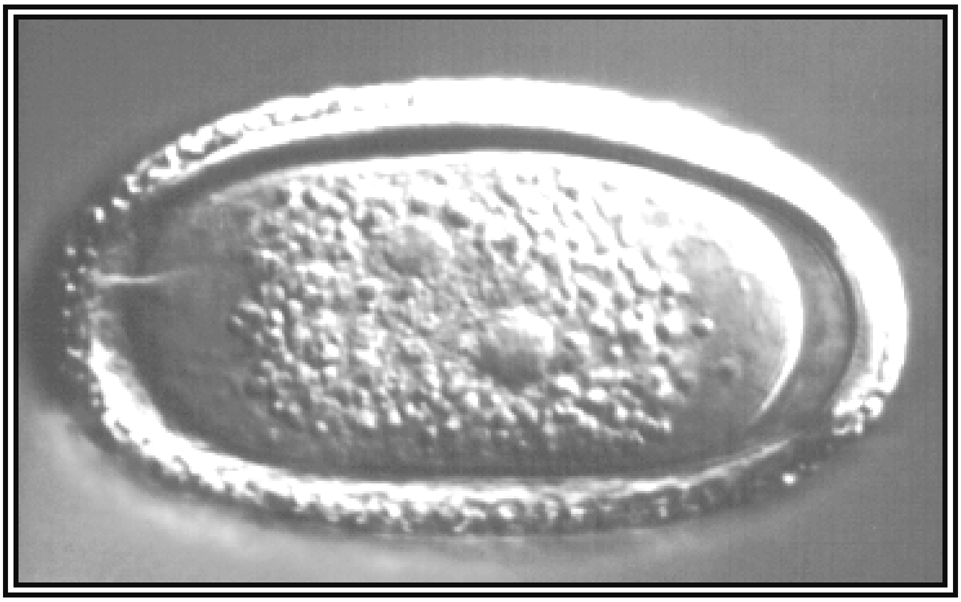


A large lesion caused by *Eustrongylides tubifex* in a yellow perch.

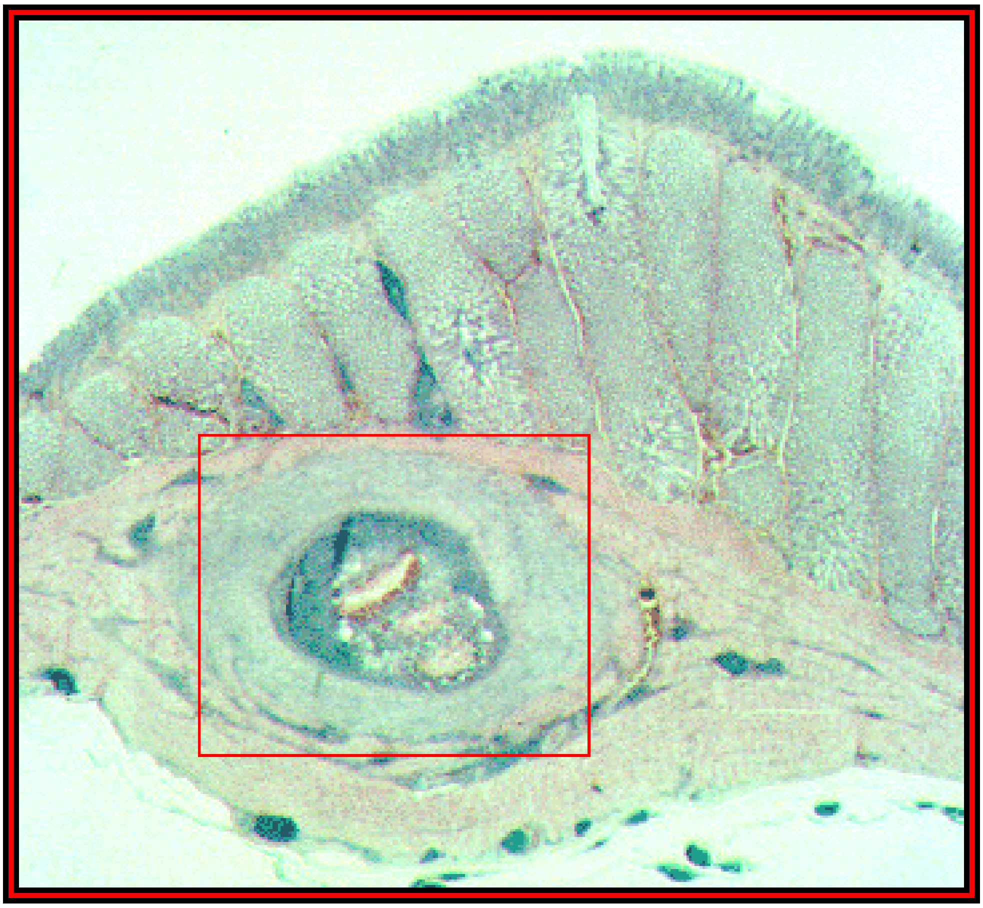


Eustrongylides tubifex in the stomach of an experimentally infected catfish.

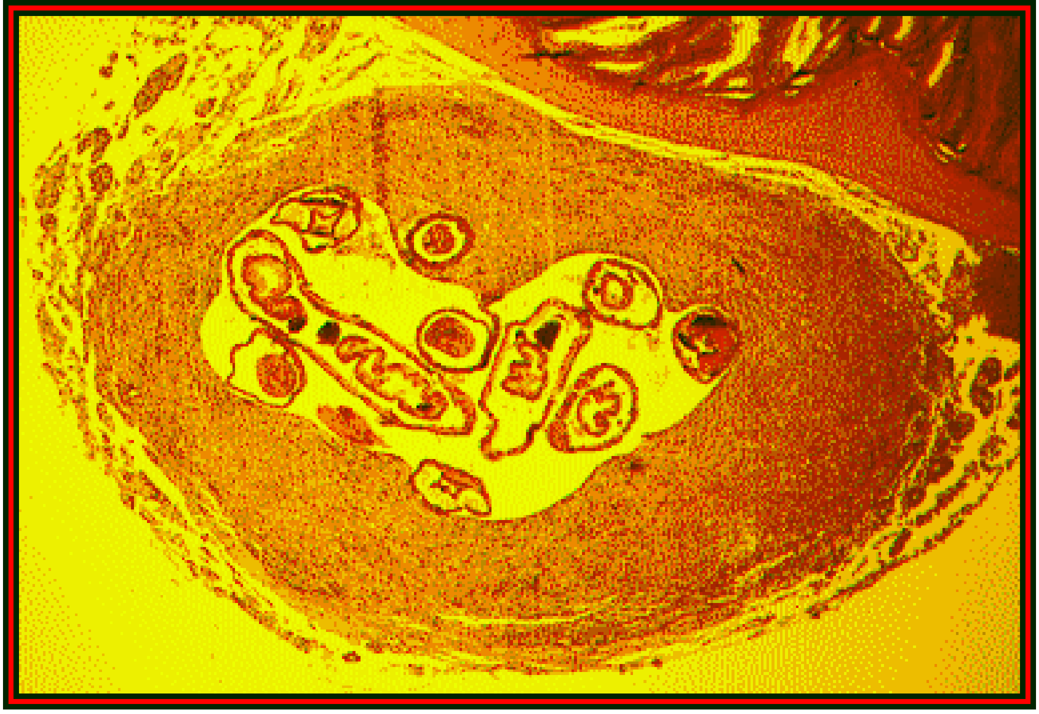
The following images were scanned from slides provided by Dr. Lena Measures, Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, QC, Canada, and used with permission. Some of the scanned images were modified slightly for this web site.


A fertilized, unembryonated egg of *Eustrongylides tubifex*.

An embryonated (larvated) egg of *Eustrongylides tubifex*.



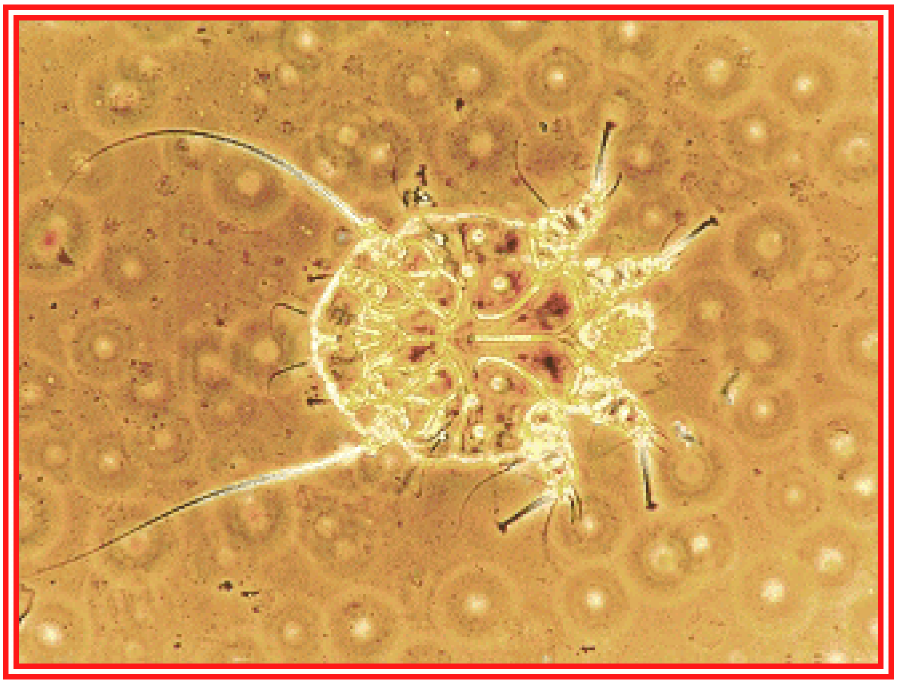
Histological section of the proventriculus of a Common Merganser 30 days post-infection with *Eustrongylides tubifex* (red square).



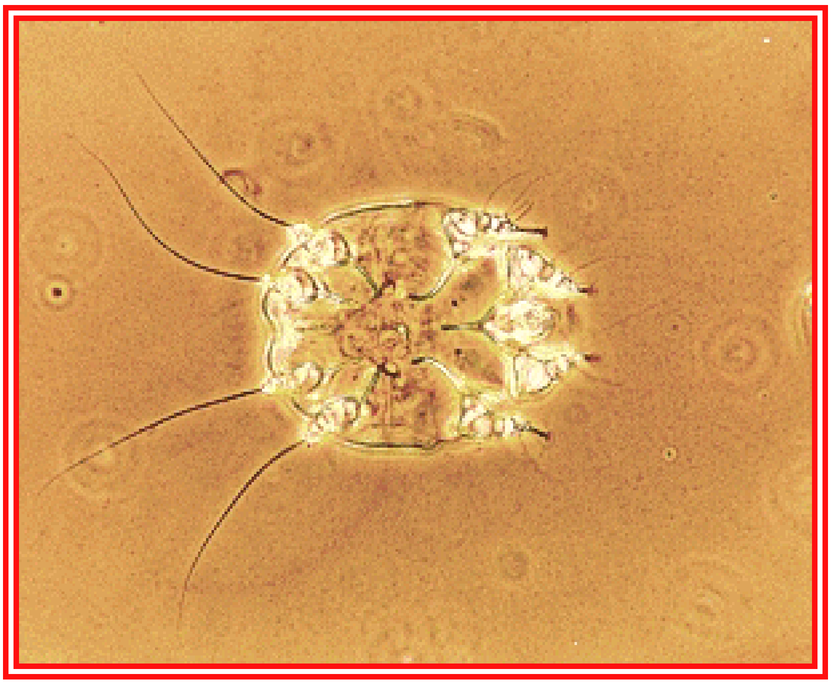
Histological section of *Eustrongylides tubifex* in a naturally infected pumpkin seed fish from Ontario.

Notoedres cati
(face mange)

This species is similar in appearance to *Sarcoptes scabiei*. *N. cati* is the primary cause of mange in cats. It will also infect dogs, but apparently will not infect humans. Known as 'face mange,' or more correctly as 'notoedric mange,' the infection usually begins at the tips of the ears, progresses over the face and, if untreated, over the body.



A female *Notoedres cati*. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)



A male *Notoedres cati*. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

A cat with notoedric mange. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Graphic Images of Parasites

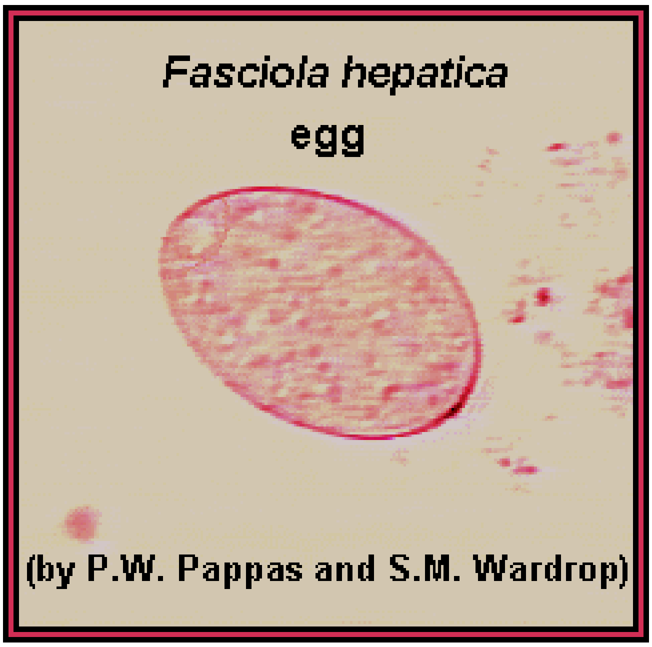
Fasciola hepatica

(the sheep liver fluke)

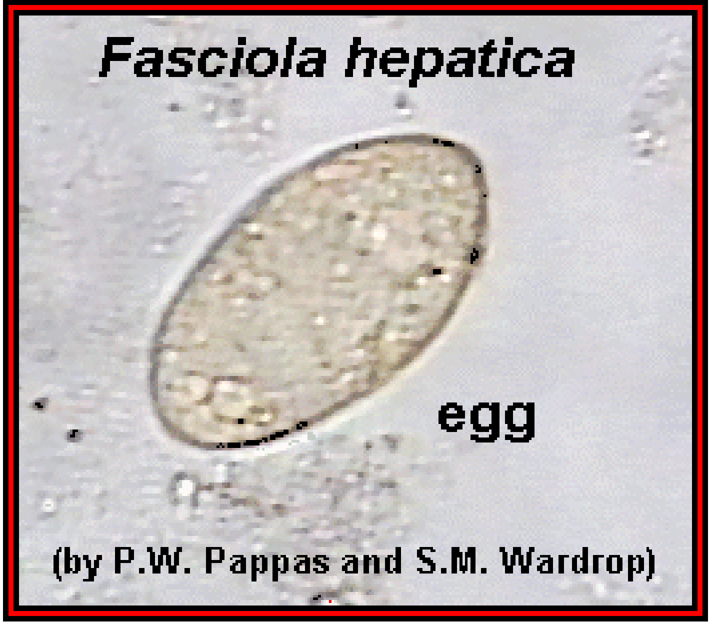
The common name of this parasite, the "sheep liver fluke," is somewhat misleading since this parasite is found in animals other than sheep (including cattle and humans), and the parasite resides in the bile ducts inside the liver rather than the liver itself. This species is a common parasite of sheep and cattle and, therefore, relatively easy to obtain. Thus, in introductory biology or zoology courses, it is often used as "THE" example of a digenetic trematode. This species has been studied extensively by parasitologists, and probably more is known about this species of digenetic trematode than any other.

The adult parasites reside in the intrahepatic bile ducts, produce eggs, and the eggs are passed in the host's feces. After passing through the first intermediate host (a snail), cercariae encyst on vegetation. The definitive host is infected when it eats the contaminated vegetation. The metacercaria excysts in the definitive host's small intestine, and the immature worm penetrates the small intestine and migrates through the abdominal cavity to the host's liver. The juvenile worm penetrates and migrates through the host's liver and finally ends up in the bile ducts (view a diagram of the life-cycle). The migration of the worms through the host's liver, and the presence of the worms in the bile ducts, are responsible for the pathology associated with fascioliasis.

Fasciola hepatica is found in parts of the United States (view distribution), as well as in Great Britian, Ireland, Europe, the Middle East, the Far East, Africa, and Australia. Fascioliasis in sheep and cattle results in animals that show low productivity (low weight gain, low milk production, etc.). Also, in many countries, livers from animals infected with *F. hepatica* are condemned as unsuitable for human consumption. This not only results in a significant economic loss to ranchers and farmers, but it also results in the loss of an important source of protein. The infection can be diagnosed by finding eggs in the feces of animals, but the eggs are difficult to differentiate from closely related species such as *Fasciolopsis buski*. Several immunological methods for diagnosis are available.



Fasciola hepatica egg; approximate size = 140 µm in length.



Fasciola hepatica egg.

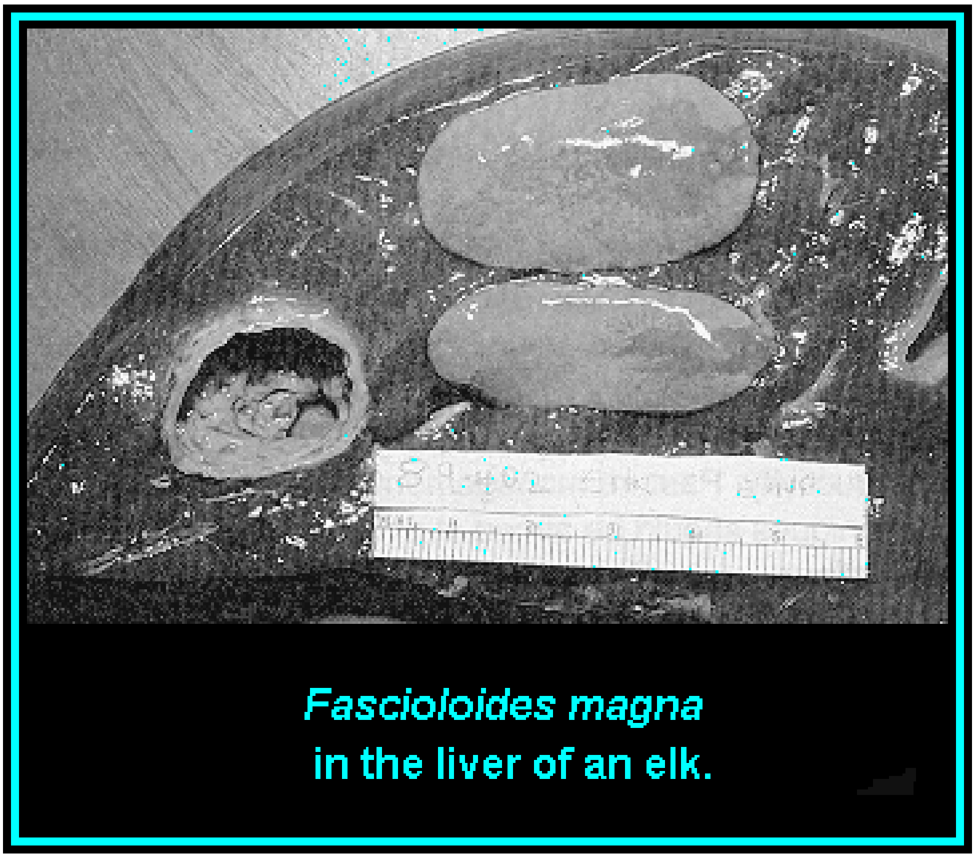
Another example of a *Fasciola hepatica* egg, showing the operculum. (Original image from: The Atlas of Medical Parasitology.)

A stained whole mount of an adult *Fasciola hepatica*; approximate length = 20 mm. The internal organs of this species are characteristically highly branched, thus making it very difficult to differentiate the various internal organs. Click here to view a labeled image of this parasite, or here to view a labeled line drawing.

Graphic Images of Parasites

Fascioloides magna

Fascioloides magna is a parasite of ruminants and found throughout North America. It is a large parasite, measuring up to 1 inch (25 mm) wide and 4 inches (100 mm) long. The life cycle of this parasite is similar to that for *Fasciola hepatica*, and the parasite can be found in the liver or bile ducts of the definitive host. In those instances where the adult worms are found in the bile ducts (e.g., in deer), the parasite's eggs are passed in the host's feces. In those instances in which the parasites are found in the liver (e.g., in cattle and sheep), the eggs may be trapped in the host's liver tissue causing severe pathology. In sheep, *F. magna* can cause severe (and often fatal) liver damage because the parasite continues to migrate through the liver tissue for long periods of time. Hence, areas in which deer serve as a natural reservoir for this parasite may not be unusable for rearing sheep or other livestock.



Two *Fascioloides magna* (directly above the ruler) which were removed from the "capsule" on the left side of the liver. The flukes are generally found encapsulated in pairs. (Original photo by M.J. Pybus, Alberta Fish and Wildlife.)

Graphic Images of Parasites

Fasciolopsis buski

Hulda Regehr Clark claims that this parasite causes "all diseases," cancer, and HIV and AIDS, and several web sites use these claims in their advertisements to sell various "cures" for these diseases. There are no peer-reviewed, published, scientific studies demonstrating that *Fasciolopsis buski* causes any of these diseases in humans. Furthermore, there are no peer-reviewed, published, scientific studies demonstrating that the various treatments, tinctures, cleanses, electrical devices (e.g., the "Zapper"), etc., sold through these web pages have any therapeutic value.

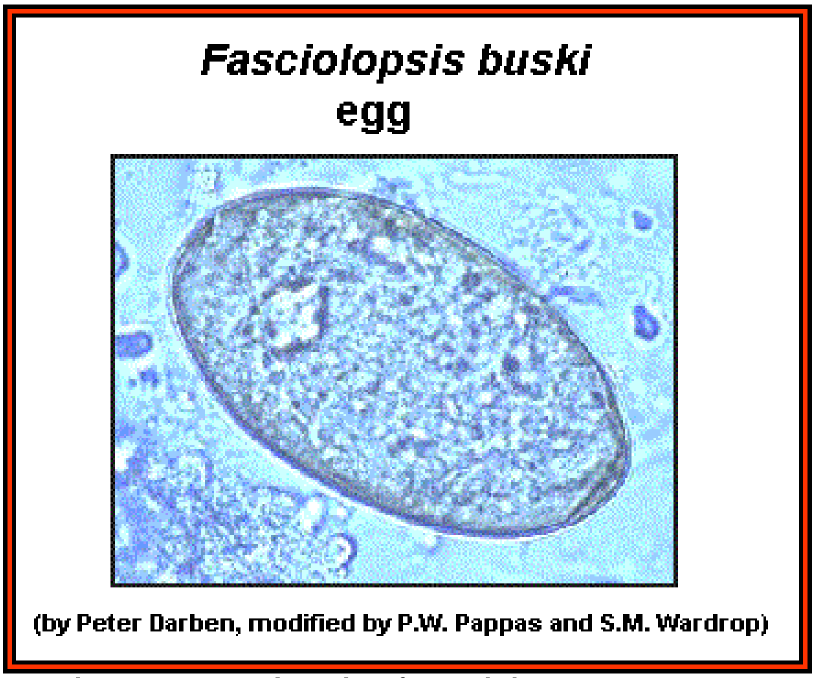
If you would like further information on Hulda Clark's "bizarre claims," and her current legal troubles, please check the "Quackwatch" or "A Closer Look at Hulda Regehr Clark" web site.

Fasciolopsis buski lives in the small intestine of humans and pigs. Measuring up to 80 mm in length, it is one of the largest trematodes found in humans. This parasite is found in many countries in the Orient and, as with many other parasites that infect humans, pigs serve as a reservoir host.

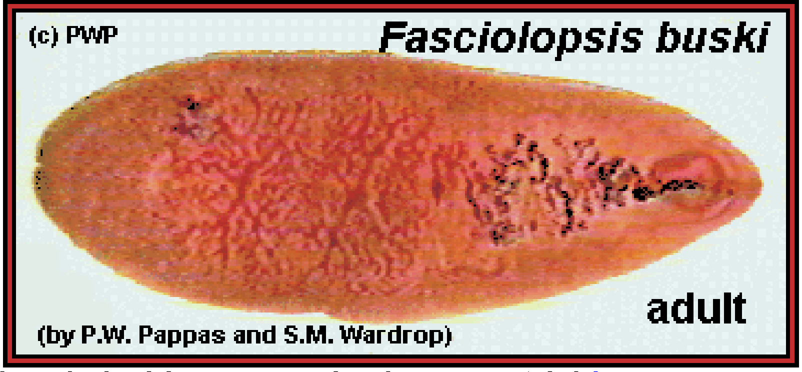
The life cycle of this parasite is similar to that of *Fasciola hepatica*. The worms produce eggs (up to 25,000 eggs per worm per day) that are passed in the host's feces. The first intermediate host is a snail, and the cercariae that emerge from the snail encyst on vegetation. Humans are infected with then eat vegetation contaminated with metacercariae. Click here to view a diagram of the life cycle.

Chronic infections with this parasite lead to inflammation, ulceration, hemorrhage, and abscesses of the small intestine, and these can ultimately lead to the host's death. Diagnosis of the disease is based on recovering eggs in the host's feces.

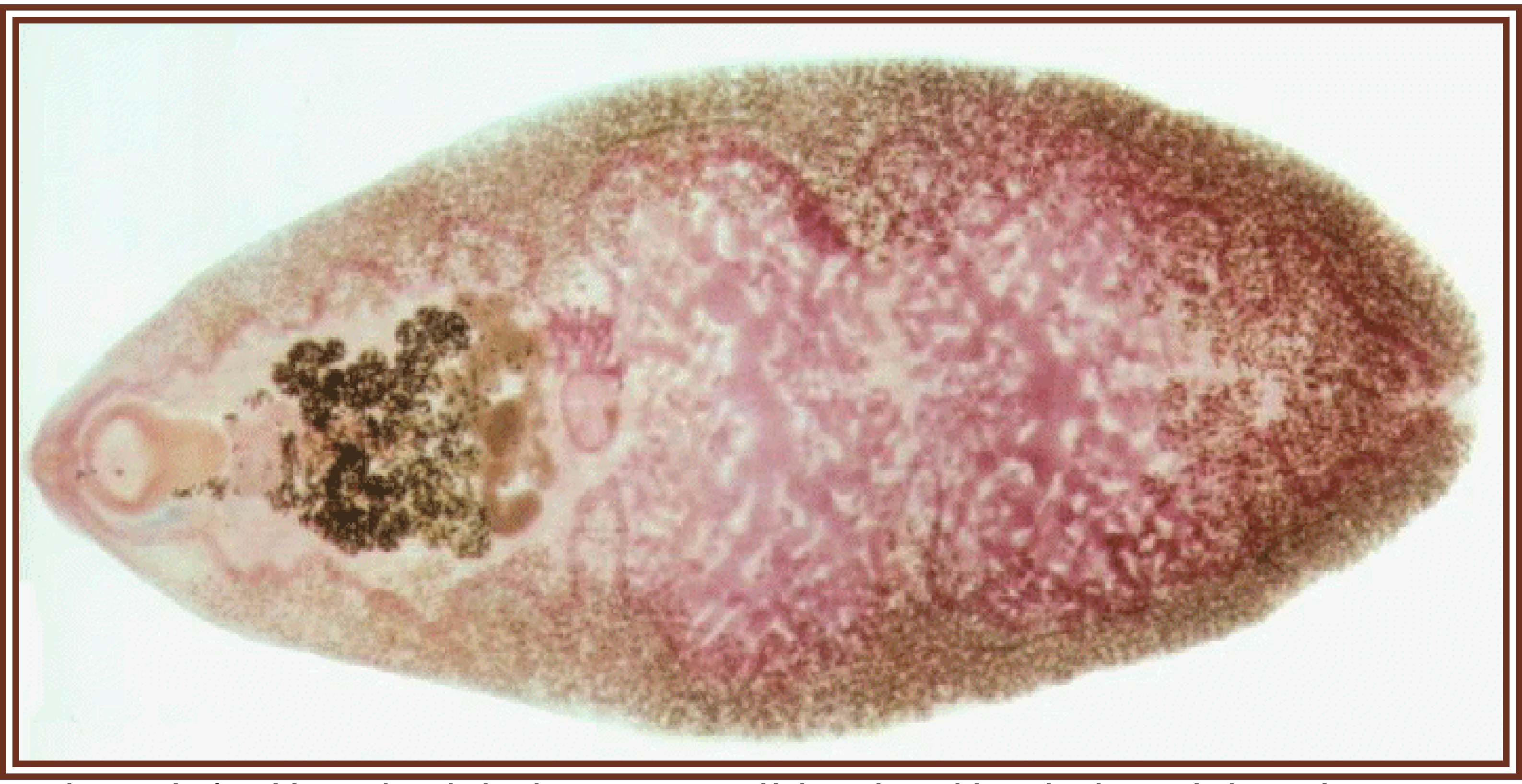
Several books and a number of web sites state that this parasite either causes directly or is associated with an increased risk of cancer, HIV, or any number of other diseases in humans. There is absolutely no evidence whatsoever that this parasite causes cancer, HIV, or any other disease in humans.



Fasciolopsis buski egg. The egg is very similar to that of *Fasciola hepatica*; approximate size = 130 µm in length.



Stained whole mount of a *Fasciolopsis buski* adult; approximate length = 50 mm. (Click here to view a second, labeled image of this species).



Another example of an adult *Fasciolopsis buski*. This specimen is stained lighter and is much larger than the example above, and some organs are seen more easily. (Original image from Taipei Medical College Parasitology web site, and modified for use.

Giardia lamblia

(giardiasis)

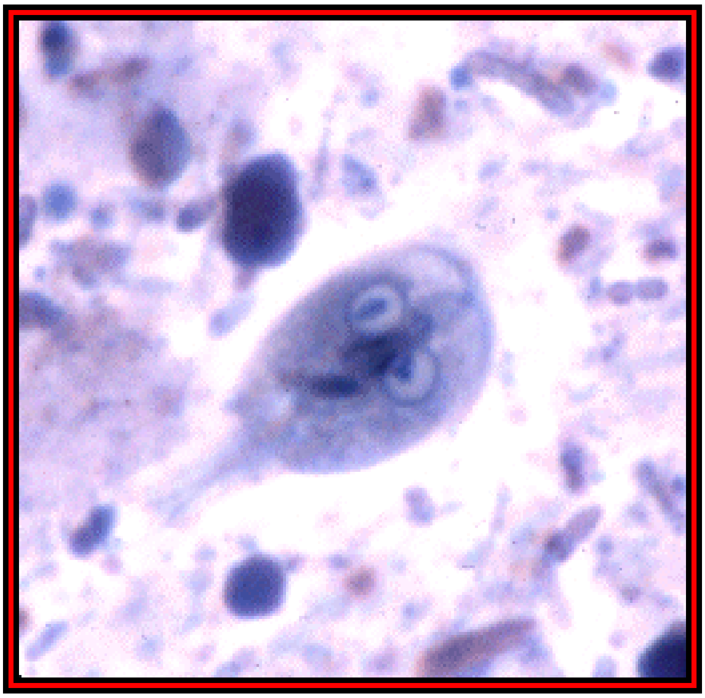
Giardia lamblia trophozoites live in the small intestine of the host. Cysts, which are resistant to adverse environmental conditions, are passed in the feces of an infected host, and the next host is infected when it ingests cysts in food or water contaminated with feces (view a diagram of the life cycle). Giardiasis is diagnosed by finding cysts or trophozoites in the feces, and both life cycle stages have a characteristic appearance. The trophozoites average about 15 µm in length, have a distinct "tear-drop" shape and two nuclei at the anterior end. The characteristic shape of the trophozoite is particularly interesting when they are viewed with an scanning electron microscope (view SEM). People who see *G. lamblia* under the microscope often say that it appears that the trophozoites are "staring back at them." The trophozoites also contain a dark transverse rod, the axostyle, which seems to be a supportive element. The cysts average about 13 µm in length, are oval, and contain two nuclei and remnants of the axostyle. Because of these unique characteristics, *G. lamblia* is one of the easiest intestinal protozoans of humans to diagnose.

Unlike *Entamoeba histolytica* which can invade the tissues of the large intestine, *G. lamblia* does not invade the tissues of the small intestine. However, the trophozoites do adhere closely to the lining of the small intestine, and in heavy infections much of the lining of the small intestine can be covered with trophozoites. The symptoms associated with giardiasis range from none (in light infections) to severe, chronic diarrhea (in heavy infections), but not dysentery.

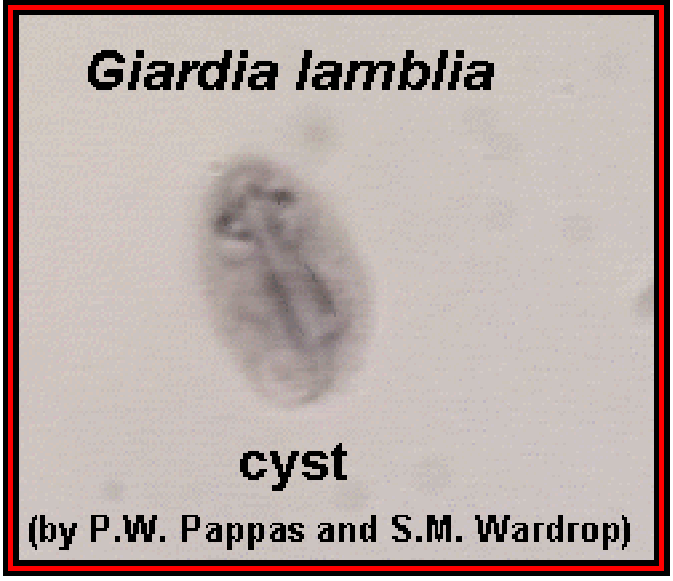
One person can pass millions of *G. lamblia* cysts each day, and most infections probably result from ingestion of water or food contaminated with human sewage. Open sewers in city streets and contamination of drinking water with this sewage undoubtedly results in many infections. However, in some countries the use of human fecal material ("night soil") as a fertilizer is also an important source of infection. Many cases of "traveler's diarrhea" are caused by *Giardia*. Even in developed countries potable water can be contaminated with small amounts of sewage, especially when septic systems are built too close to wells. Thus, it is not surprising that *G. lamblia* is found throughout the world.

Every year many people return from camping trips to find that they are suffering from giardiasis, but the source of these infections remains uncertain. Some authorities believe that *Giardia* infects a number animals other than humans, particularly beavers, and that campers contract giardiasis from drinking stream water contaminated with cysts from beavers (hence, "beaver fever"). Other authorities, however, believe that these cases result from streams contaminated with human feces. Although mountain streams may appear to be "sparkling clean," some camper upstream may be using your drinking water as a toilet! Thus, no matter what it looks like, stream water should be treated before drinking. Boiling will kill *Giardia* cysts, and there are commercially available filters that will remove the cysts from water.

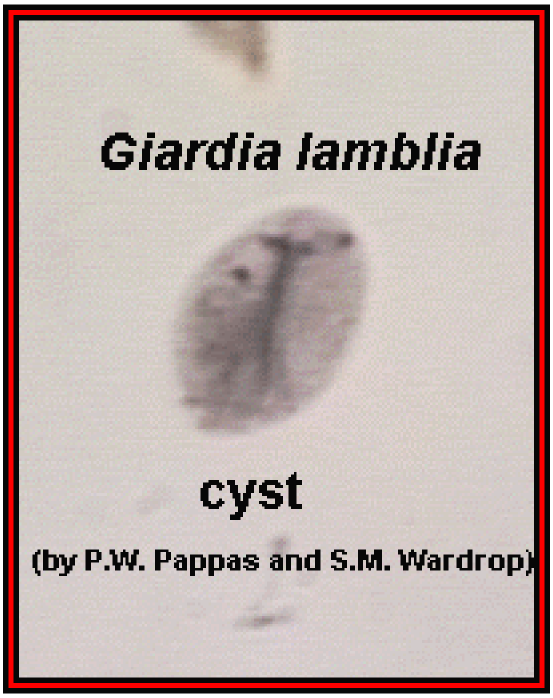
Giardia lamblia trophozoite; approximate size = 14 µm. The two nuclei and clearly visible, but the characteristic "tear-drop" shape is not visible in this plane of focus.



Another example of a *Giardia lamblia* troph. The two nuclei are easy to see in this image. (Original image from a Japanese language site tentatively titled "Internet Atlas of Human Parasitology."



Giardia lamblia cyst; approximate size = 14 µm. The nuclei and axostyles are clearly visible.



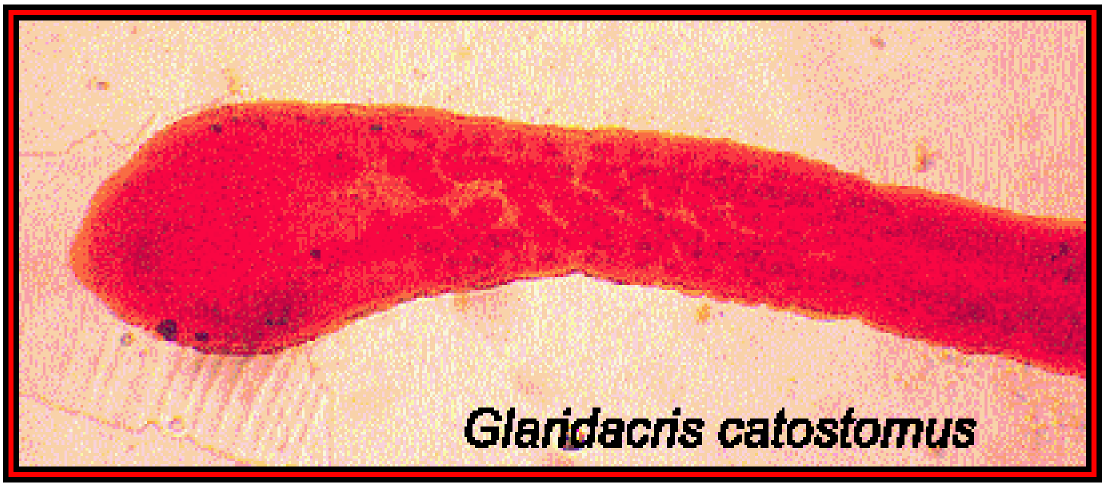
Giardia lamblia cyst; approximate size = 16 µm.

Glaridacris sp.

The bodies of most tapeworms consist of a chain of proglottids, each of which is an independent reproductive unit. Such worms are said to be "polyzoic." There are, however, a number of species of tapeworms that consist of but a single proglottid. Such tapeworms are said to be "monozoic," and they belong to the order Caryophyllidea.

The life cycle of *Glaridacris catostomus* involves fish as the definitive host and an annelid (segmented worm) as the intermediate host.

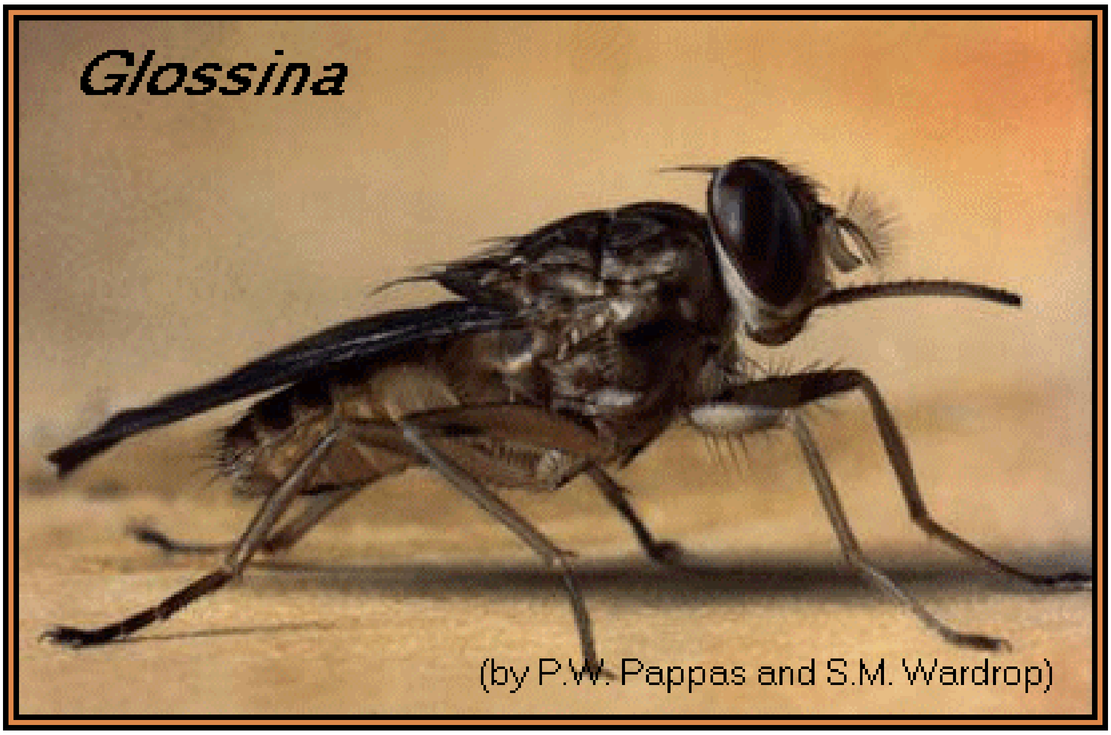
The two images below represent the anterior and posterior aspects of a stain whole mount of a complete *Glaridacris catostomum*. Unfortunately, many of the internal organs can not be seen, but this preparation shows that the organism is monozoic.



Glossina spp.

(tsetse or tsetse fly)

Of the approximately 23 species of *Glossina* recognized, all but three will transmit trypanosomes of mammals. Several species are particularly important vectors of African trypanosomiasis ("sleeping sickness") in humans. Adult tsetse flies typically measure 7 to 14 mm long.



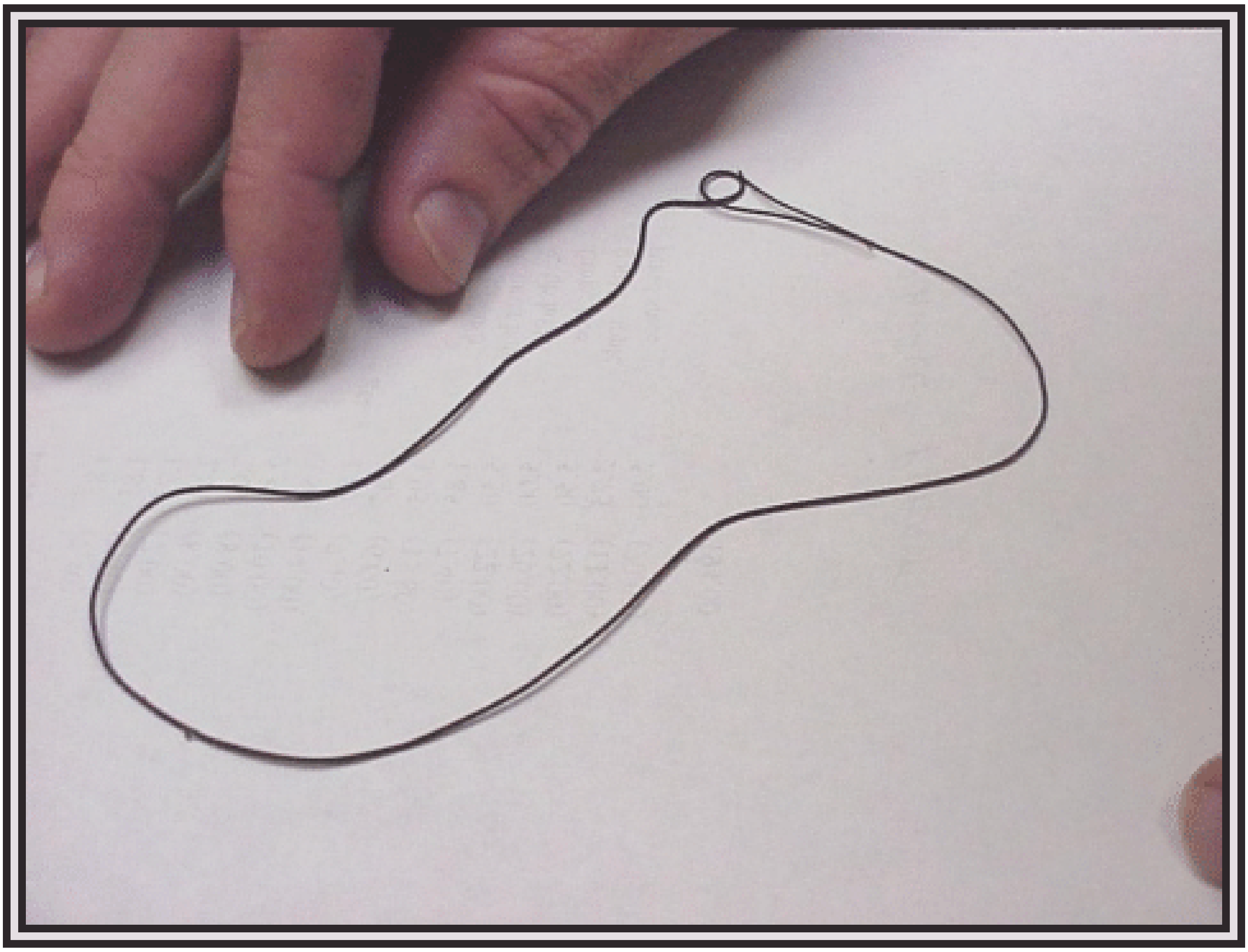
A tsetse or tsetse fly (*Glossina* sp.)

Graphic Images of Parasites

Nematomorpha
(nematomorphs or horsehair worms)

The phylum Nematomorpha contains approximately 320 species. The adult forms of these worms are commonly referred to as "horsehair worms," a name that reflects the superstition that these worms arise from horsehair.

Adult nematomorphs are quite large and can be found in aquatic and marine environments. The adult female produces eggs which hatch and mature into juveniles. The juvenile then penetrates an appropriate arthropod host. For aquatic nematomorphs, beetles, crickets, roaches, and grasshoppers will serve as the host, while crabs serve as the host for marine forms. In the arthropod host the juvenile matures into an adult worm, and the adult worm emerges when the arthropod host is in (near) water.



An adult horsehair worm (*Gordius* sp.). (Original image from "Featured Creatures" and copyrighted by the University of Florida).

Gregarina sp.

Members of the genus *Gregarina* are commonly found as parasites in insects, particularly beetles, and they have a direct life cycle. The beetle is infected when it ingests a "spore" containing sporozoites. The sporozoites form gamonts, the gamonts fuse (a process called syzygy), followed by formation of gametes and fertilization. The resulting zygote eventually forms sporozoites (and the "spore").

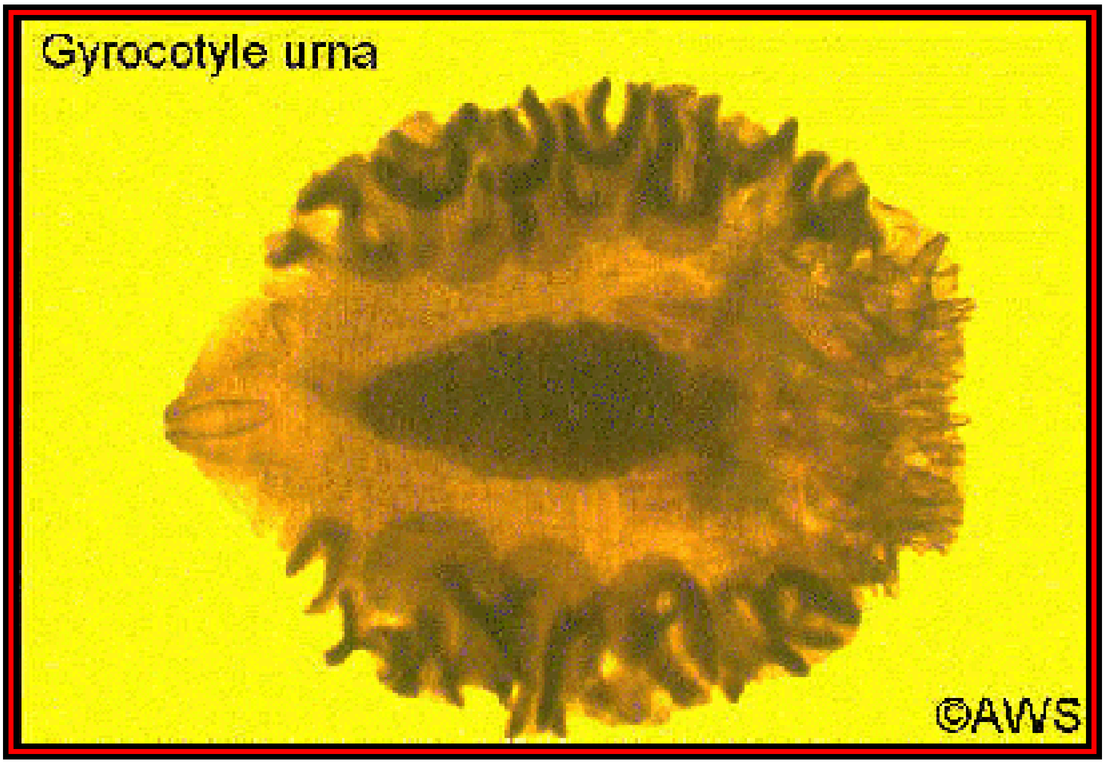
A histological section of an insect gut showing gamonts of *Gregarina* sp. The gamont is composed of two parts that appear to be separated by a septa (see bottom center of image). The smaller section is called the protomerite, and the larger section is called the deutomerite.

Gyrocotyle sp.

The tapeworms were, historically, divided into two major groups (subclasses), the "true tapeworms" or eucestodes and the cestodarians. The cestodarians, and *Gyrocotyle* in particular, seem to be related to the tapeworms, but some authorities believe that the cestodarians are more closely related to the monogenetic trematodes. The following statement indicates very dynamic nature of the systematics of this group:

> "The Gyrocotylidea have traditionally been placed with the Amphilinidea in a subclass Cestodaria of the Class Cestoidea. Present opinion places them as a sister group of the cohort Cestoidea in the infraclass Cestodaria, and the Cestodaria is a sister group of the infraclass Monogenea in the subclass Cercomeromorphae." (Roberts, L.S., and Janovy, J., Jr. (1996) *Foundations of Parasitology*, 5th ed. Wm. C. Brown, Publishers).

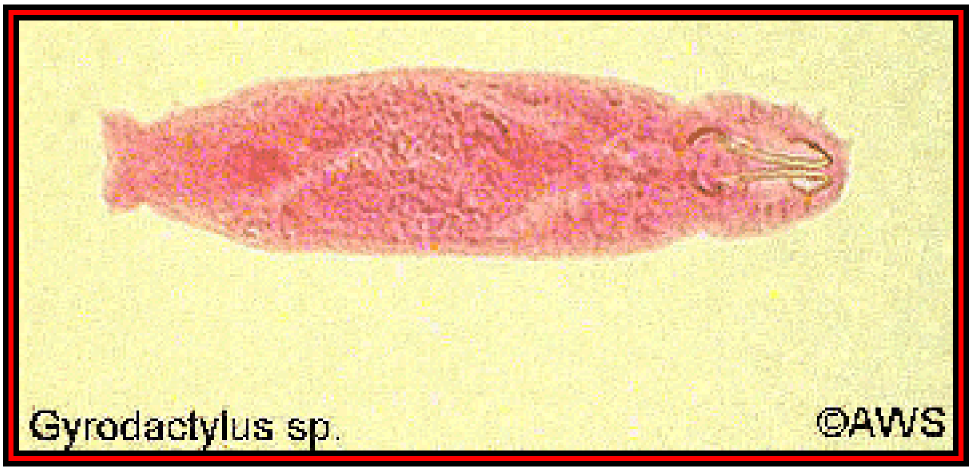
Gyrocotyle is a parasite of the intestinal tracts of chimaeroid fishes. The adult worms are large, measuring up to 60 mm in length. The complete life cycle of this species has not been elucidated.



A whole mount of *Gyrocotyle urna*, a cestodarian. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Gyrodactylus sp.

Members of this diverse genus are parasites of the gills of fish, and they can be a particular problem in fish ponds. Members of this genus are unusual in that the eggs hatch *in utero*, and the adult worm gives birth to "subadults" (i.e., they're viviparous).

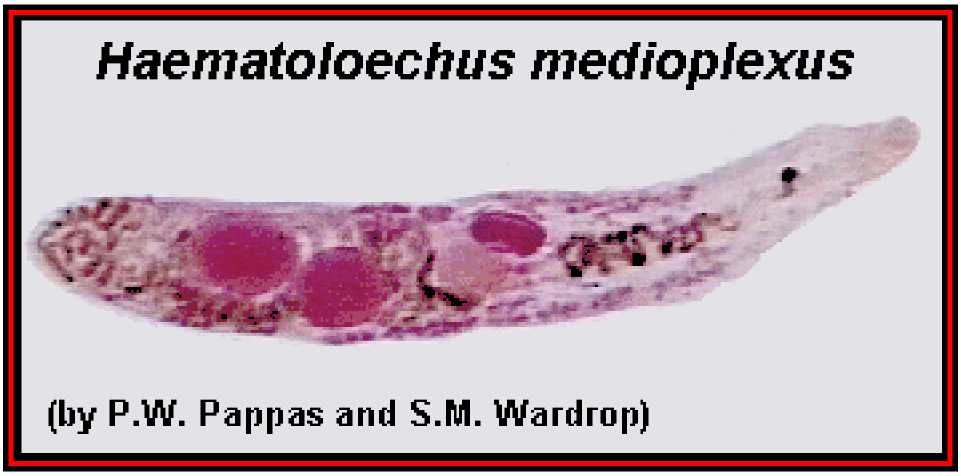


A whole mount of an adult *Gyrodactylus* sp. Note the large hooks or "anchors" at the posterior end (right side of image). Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Graphic Images of Parasites

Haematoloechus medioplexus
(frog lung fluke)

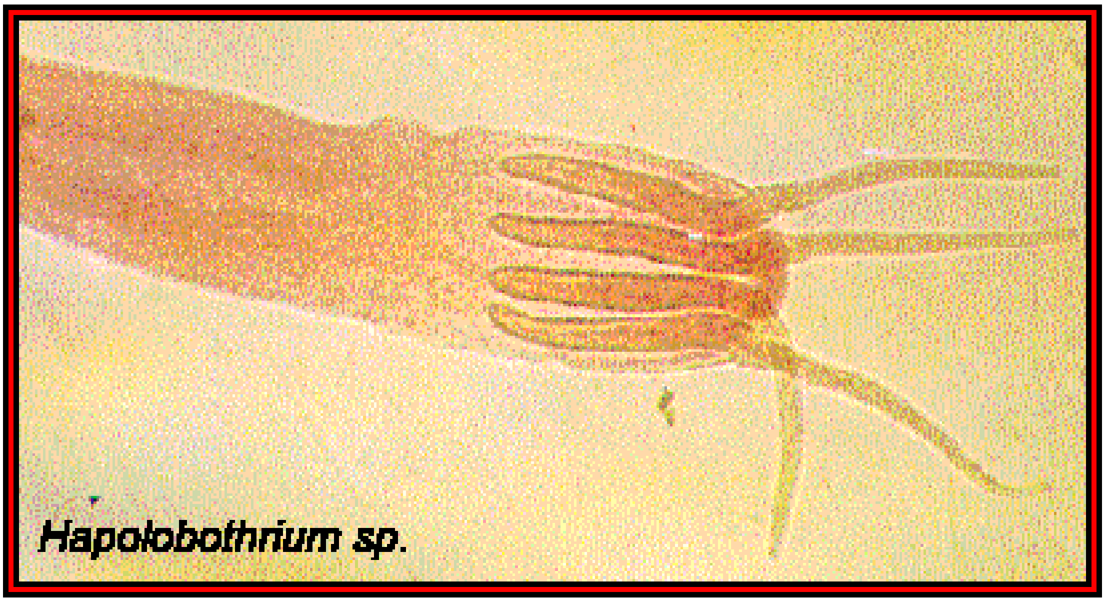
Haematoloechus medioplexus and several related species are common parasites of the lungs of frogs. This is often the first parasite that a biology student sees, since it is found commonly in the lungs of frogs that are dissected as part of introductory biology laboratories. The adult worms are 8-10 mm in length. The eggs that are produced by the worms are carried out of the frog's lung via ciliary action and into the frog's mouth. The eggs are swallowed and passed in the frog's feces. The first intermediate host is a snail, and the cercariae that are liberated from the snail enter the anus of an immature dragonfly (naiad stage). Metacercariae encyst in the muscles of the dragonfly nymph, and when the dragonfly emerges as an adult the following year the metacercariae remain. Frogs are infected when they ingest dragonfly naiads or adults harboring metacercariae (dragonfly naiads are also the second intermediate host for *Prosthogonimus macrorchis*). The immature worms are liberated in the frog's small intestine, and from here they migrate anteriorly into the frog's mouth and then down the bronchi into the frog's lungs (view diagram of the life cycle). Like *Prosthogonimus macrorchis*, *Fasciola hepatica*, and *Paragonimus westermani*, this is another example of a trematode's ability to migrate and find its appropriate location within the host's body.



Haematoloechus medioplexus, adult, stained whole mount; approximate size = 7 mm in length. (Click here to view a labeled image of this species.)

Haplobothrium sp.

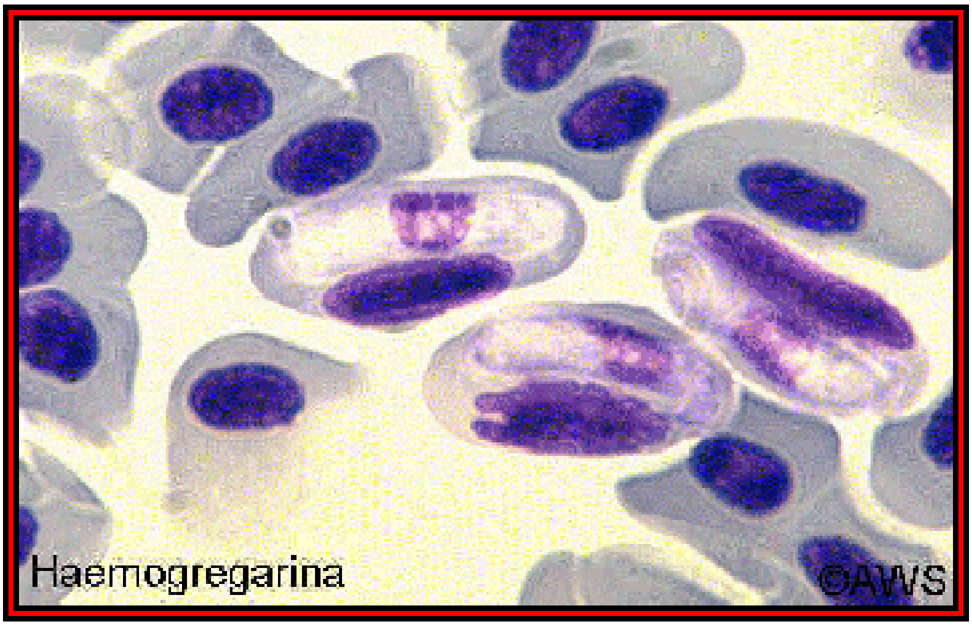
Members of this genus resemble the trypanorhynchid cestodes, but they are clearly different and are placed in the the family Haplobothriidae. In this genus the scolex has well developed tentacles, but the suckers (called bothridia) are actually located at the tips of the tentacles. These tapeworms are parasites of fresh water fish.



A stained whole mount of the scolex of *Haplobothrium* sp. This specimen was recovered from *Amia calva*. Although the suckers can not be seen in this preparation, the characteristic tentacles are visible.

Hemogregarina sp.

The "hemogregarines" are vector borne blood parasites of fish, amphibians, reptiles, birds, and a few mammals. Depending on the species, various species of arthropods serve as vectors.



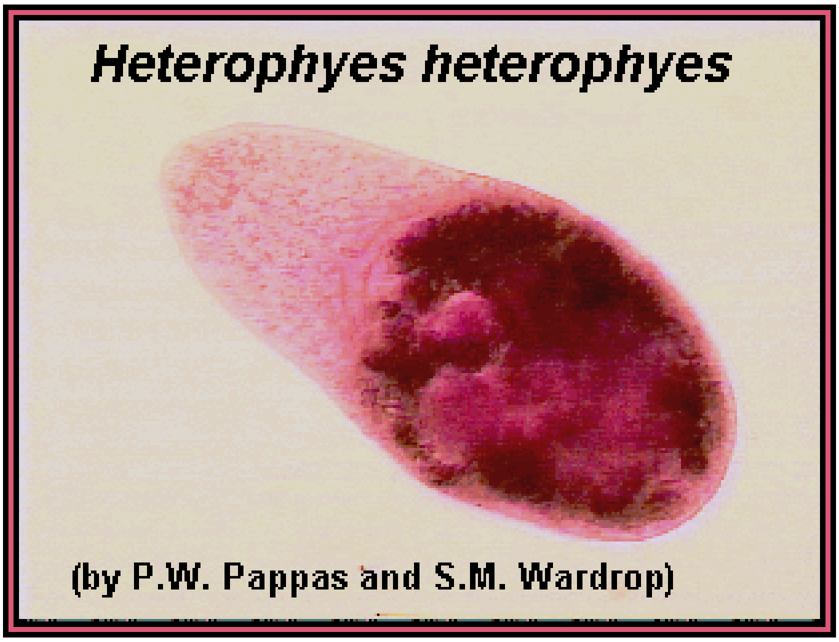
Hemogregarina sp. in a blood smear. Note that the host's red blood cells have nuclei. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Graphic Images of Parasites

Heterophyes heterophyes

Heterophyes heterophyes is a digenetic trematode that resides in the small intestine of its host. It infects humans, as well as cats, foxes, and dogs. The parasite is one of the smallest trematodes infecting humans, averaging about 1.5 mm in length. Two intermediate hosts are required for the life cycle, the second intermediate host being an estuarine fish (e.g., mullet), and the definitive host is infected by ingesting raw or undercooked fish (view diagram of the life cycle). The parasite is distributed throughout parts of Africa and southeast Asia, and it has also been imported into Hawaii. In many countries it is common to find fish infected with *H. Heterophyes* at the local fish markets.

The parasite can irritate the lining of the small intestine, resulting in diarrhea and abdominal pain. In some instances the lining of the small intestine breaks down, and the eggs produced by the parasite enter the blood stream. Once in the blood stream the eggs can be carried to other organs where they can cause significant pathology, especially in the liver, heart, and brain. Diagnosis is based on finding eggs in stool samples. However, the eggs of *H. heterophyes* appear very similar to the eggs of *Clonorchis sinensis* and *Metagonimus yokogawai*. This not only makes diagnosis difficult, but it also makes it difficult to determine how many people are really infected with this parasite.



Heterophyes heterophyes; stained whole mount. The worm measures approximately 1.3 mm in length. The posterior section of the worm is filled with eggs, thus making it difficult to see the internal organs.

Graphic Images of Parasites

Hymenolepis spp.

The genus *Hymenolepis* contains in excess of 400 species (according to some authorities), virtually all of which are found in higher vertebrates. The life cycles for most species are unknown, but it's likely that they all involve insects as the intermediate host (with a cysticercoid as the metacestode stage). Two species of *Hymenolepis* are of particular interest. *Hymenolepis nana* (referred to as *Vampirolepis nana* by some authors) is a parasite of humans. It is also found in rodents, mice in particular, and it has been widely used as a model system for the study of cestode (tapeworm) biology. *Hymenolepis diminuta* is a also a parasite of rodents, rats in particular, but it has been reported from humans on rare occasions. *Hymenolepis diminuta* has also been widely used as a model system for the study of cestode, and, arguably, more is known about this species than any other species of tapeworm.

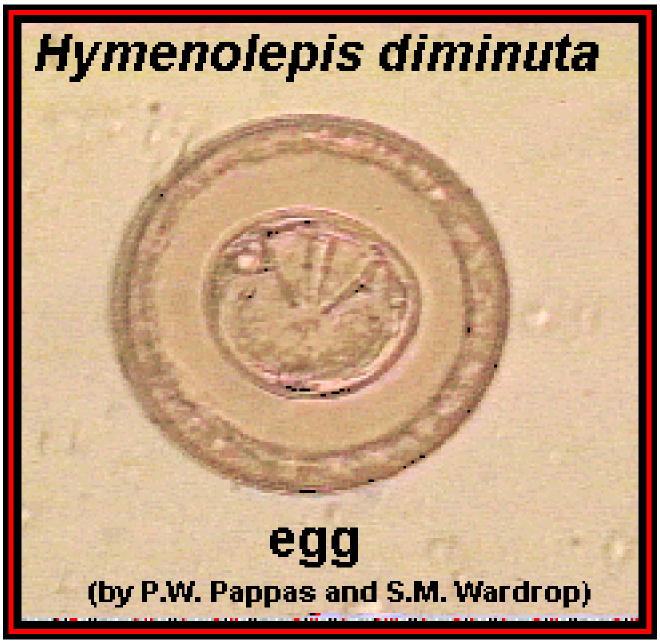
Images of *Hymenolepis nana*

Images of *Hymenolepis diminuta*

Graphic Images of Parasites

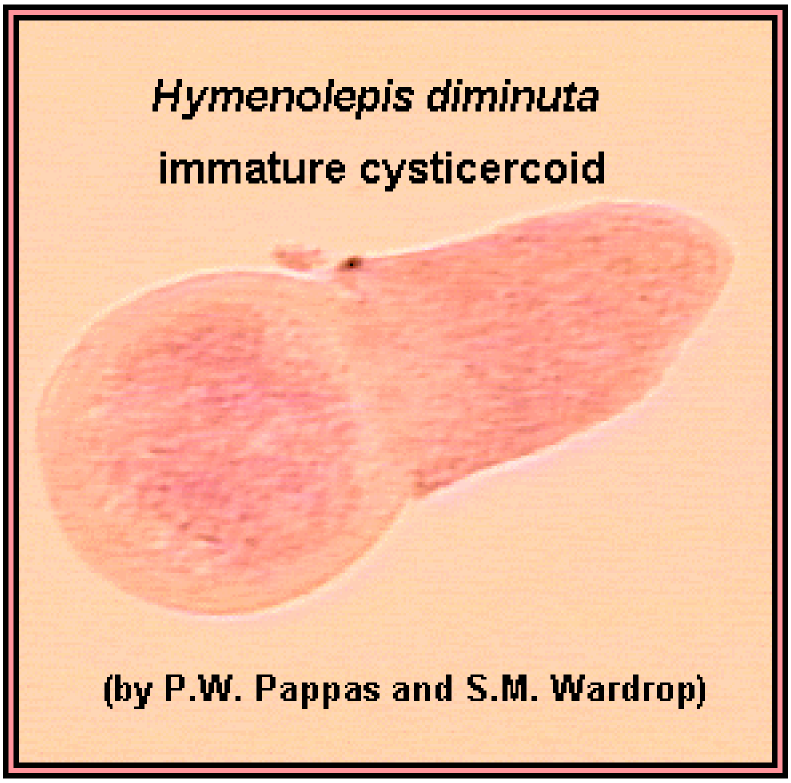
Hymenolepis diminuta

The life cycle of *Hymenolepis diminuta* involves rodents (rats primarily) as the definitive host and beetles (flour and grain beetles, *Tribolium* spp. and *Tenebrio* spp., respectively) as the intermediate host. The tapeworm's eggs are passed in the rat's feces, and beetles are infected when they eat the eggs; the metacestode stage in the beetle is called a *cysticercoid*. The rat is infected when it eats an infected beetle (view diagram of the life cycle). This tapeworm is found commonly in areas where large amounts of grain or other dry food products are stored. This species has been reported from humans on rare occasions.

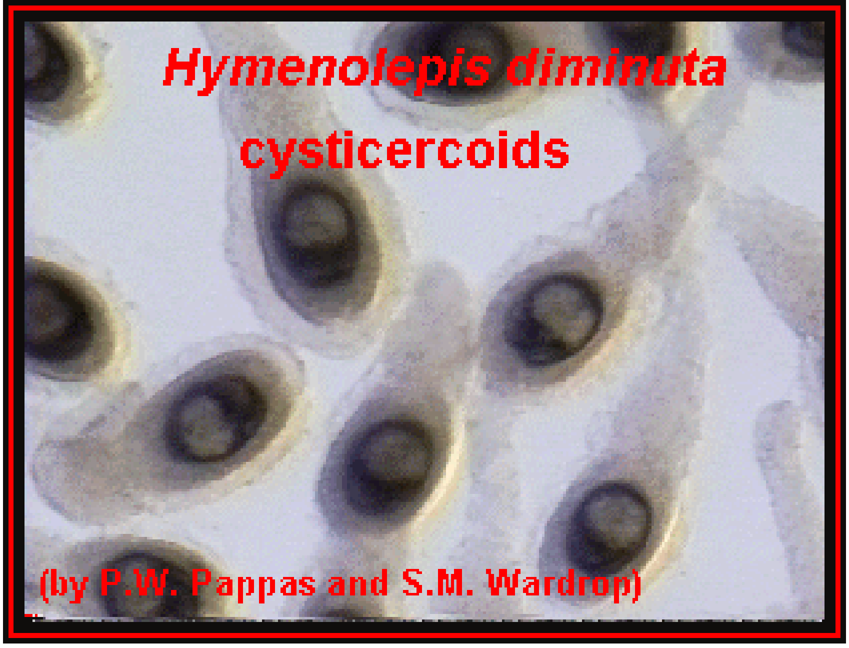


Hymenolepis diminuta egg. The six-hooked (hexacanth) larva (oncosphere) is easily visible. The egg measures approximately 60 µm in diameter.

Hymenolepis diminuta eggs. Some of the eggs in this image have been "cracked" open and the shells and larvae are clearly visible. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

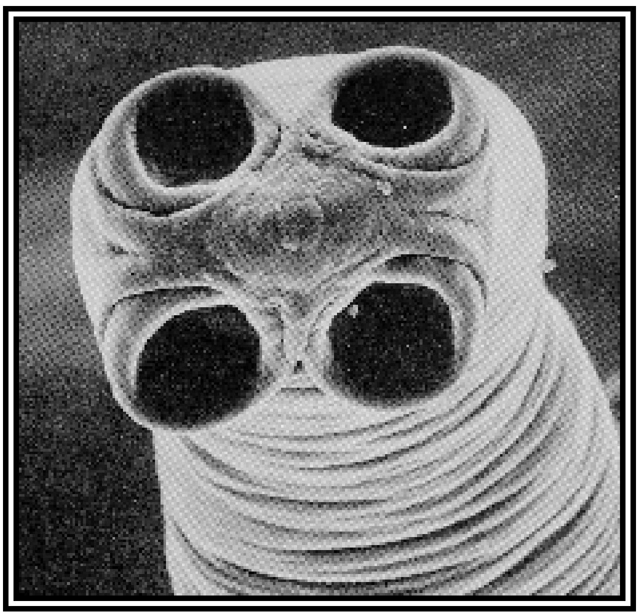


Hymenolepis diminuta cysticercoid recovered from an infected beetle 9 days following infection (stained whole mount). Compare with the following photograph of a mature cysticercoid.



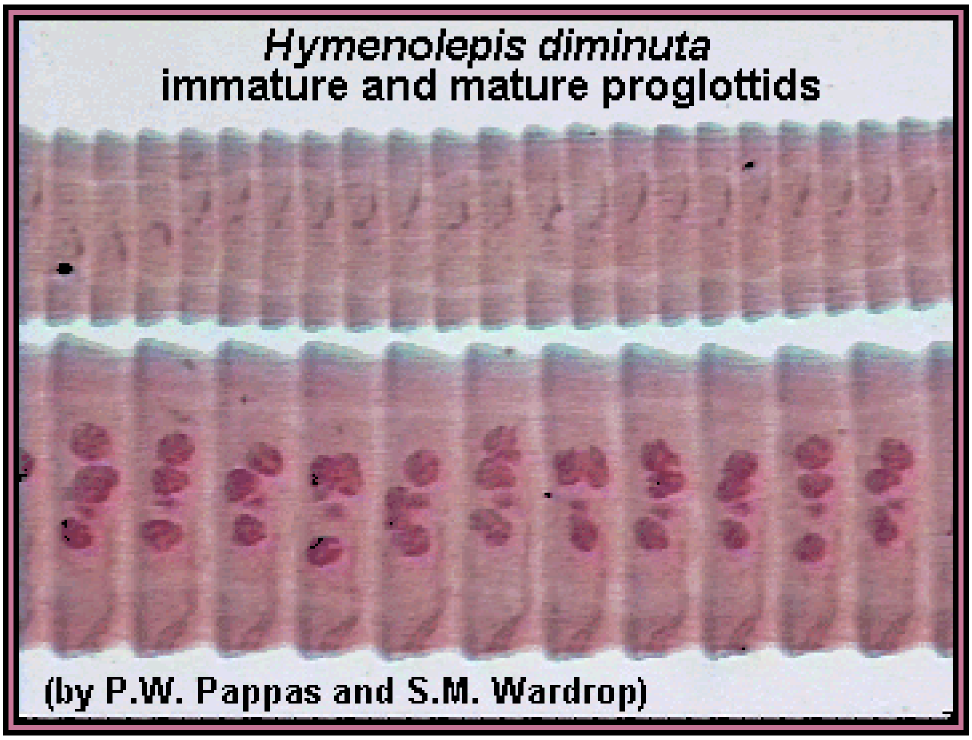
Hymenolepis diminuta cysticercoids recovered from an infected beetle 20 days following infection (unstained). The dark area in each cysticercoid represents the invaginated scolex.

A stained whole mount of the scolex of *Hymenolepis diminuta*. The scolex has four suckers (one is marked by the *), but no hooks.

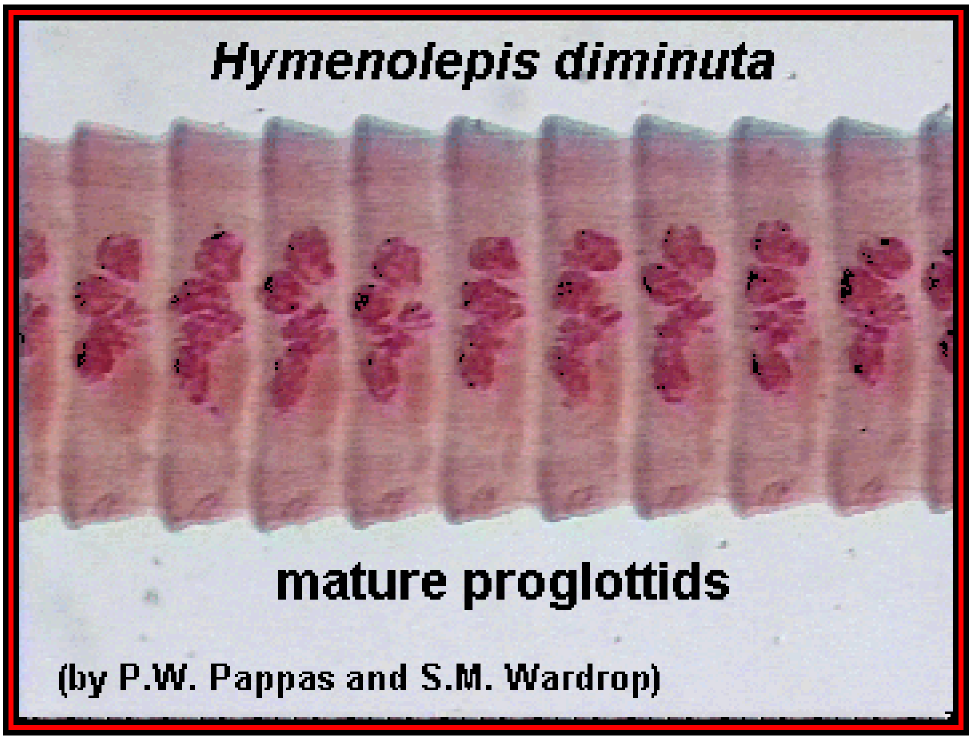


Scanning electron micrograph of the scolex of *Hymenolepis diminuta*. The four suckers, typical of a cyclophyllidean

cestode, are evident, as is the absence of an armed rostellum. Compare this with the above photograph of a stained whole mount.



Immature and mature proglottids of *Hymenolepis diminuta*.



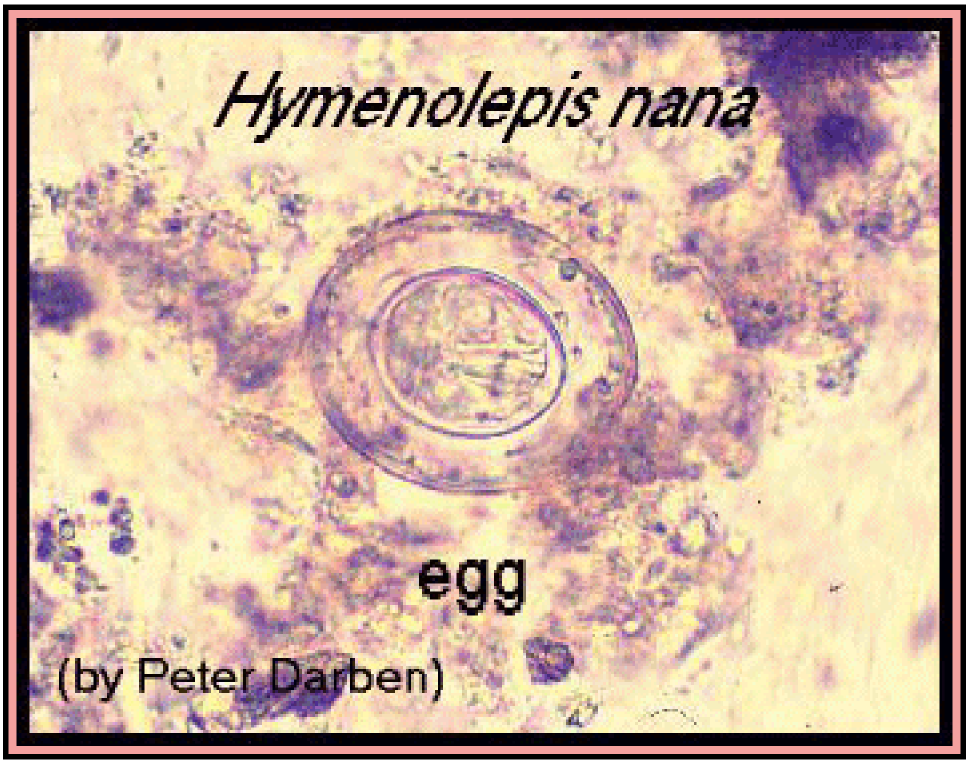
Mature proglottids of *Hymenolepis diminuta*. Click here to view another image in which the internal organs are labeled.

Hymenolepis nana

(Vampirolepis nana)

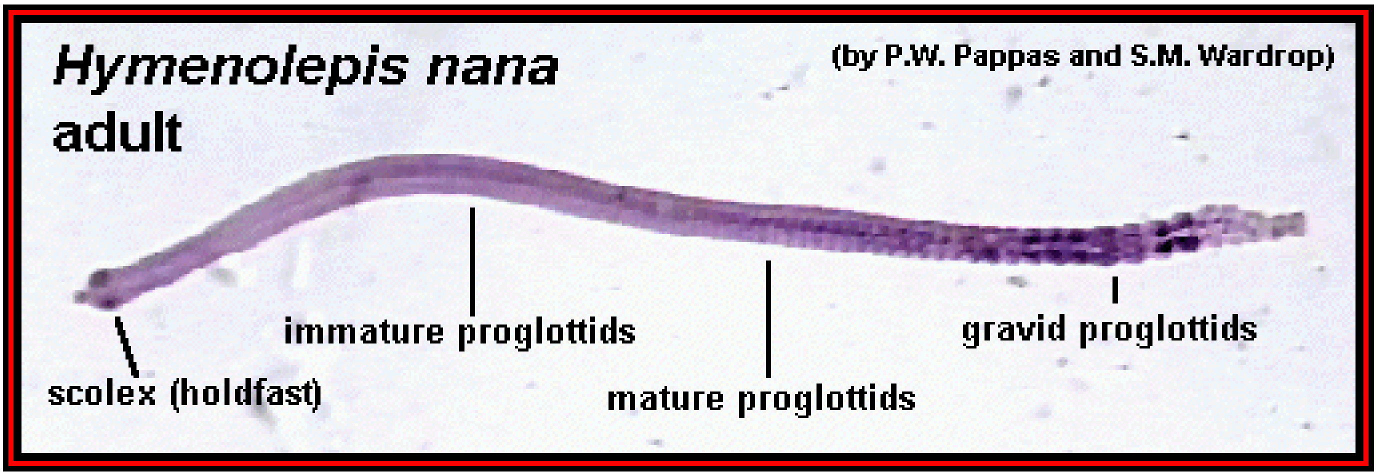
The life cycle of *Hymenolepis nana* involves humans or rodents (mice primarily) as the definitive host and beetles (flour and grain beetles) as the intermediate host. The tapeworm's eggs are passed in the definitive host's feces, and beetles are infected when they eat the eggs; the metacestode stage in the beetle is called a *cysticercoid*. The definitive host is infected when it eats an infected beetle (view diagram of the life cycle).

Unlike virtually all other species of tapeworms, the life cycle of *H. nana* does **not** require an intermediate host. If the eggs of this parasite are ingested by an appropriate definitive host, the eggs hatch in the host's small intestine, the hexacanth burrows into the tissues of the small intestine, and a cysticercoid forms. When the cysticercoid is mature it moves from the tissues into the lumen of the gut and grows to sexual maturity. With this direct life cycle, this species is uniquely adapted to grow in conditions of high host population density. Thus, this species can be a particular problem in humans in areas of high population density and close contact, and where sanitary conditions are poor. Fortunately, infections with this parasite are more of a nuisance than a problem.

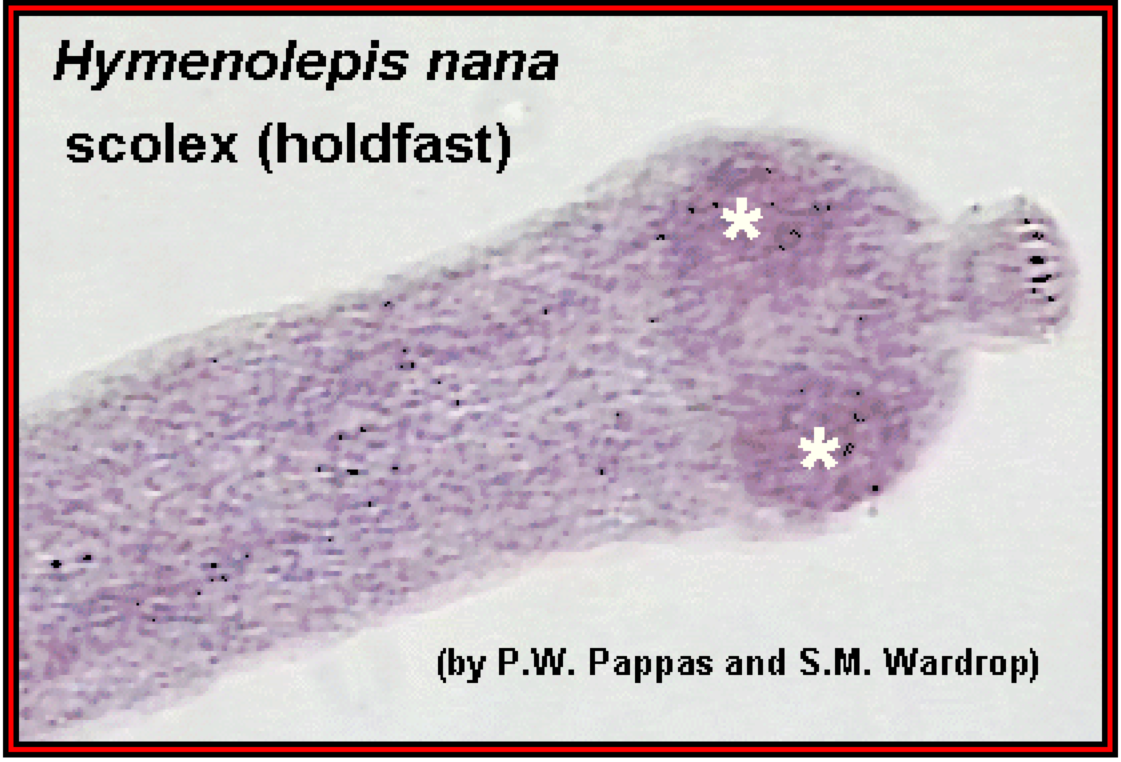


Hymenolepis nana egg. The egg measures approximately 45 µm in diameter. It can be differentiated from the egg of *H. diminuta* by the presence of "polar filaments" in the area between the outside "shell" and the internal larva.

A histological section showing a cysticercoid (*) of *H. nana* developing the the small intestine of an experimentally infected mouse.



Hymenolepis nana, adult, stained whole mount; approximate length = 35 mm. The tapeworm's body (strobila) consists of proglottids in various stages of development.



Scolex (holdfast) of *Hymenolepis nana*. The scolex has four suckers which are not visible in this plane of focus (two are marked by *), and an armed rostellum that is clearly visible. The scolex of *H. diminuta* is similar but is not armed with hooks.

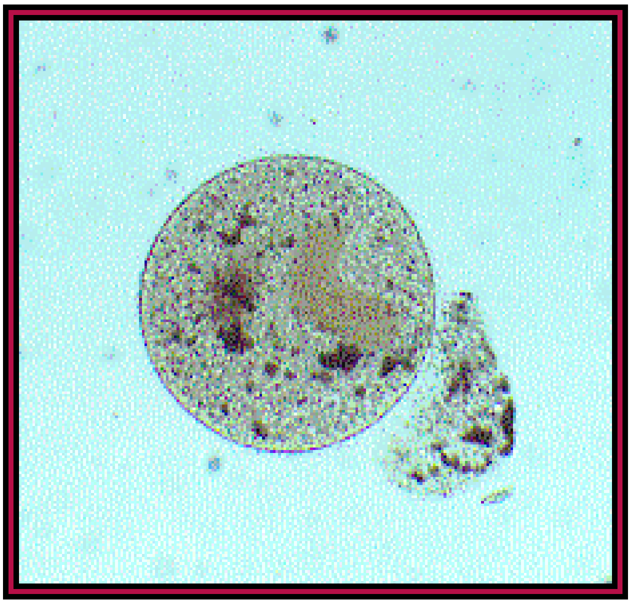
Scanning electron micrograph (SEM) of the scolex of *Hymenolepis microstoma*. This species is not found in humans, but rather in the bile ducts of rodents (mice most often). The scolex of this species is similar in appearance to that of *H. nana* (compare with the above photograph). Note the presence of four well developed suckers and the armed rostellum.

Ichthyophthirius multifiliis

(causing "ick" in fish)

This species of parasitic ciliate is well known to many aquaculturists and fish-hobbyists. It causes the disease commonly referred to as "ick," a disease that can infect and damage the skin, gills, and/or eyes of many species of fish. The parasite's life cycle is direct and simple. The trophozoites are found in pustules on the fish and escape when the pustules rupture. The trophozoites settle to the substrate, forms a "cyst," and then reproduces asexually. The cyst, now containing hundreds of "swarmers" (or tomites), breaks open, and the swarmers search for a new host. Upon contacting a new host, the swarmer or tomite burrows into the host's tissue and grows into a new pustule.

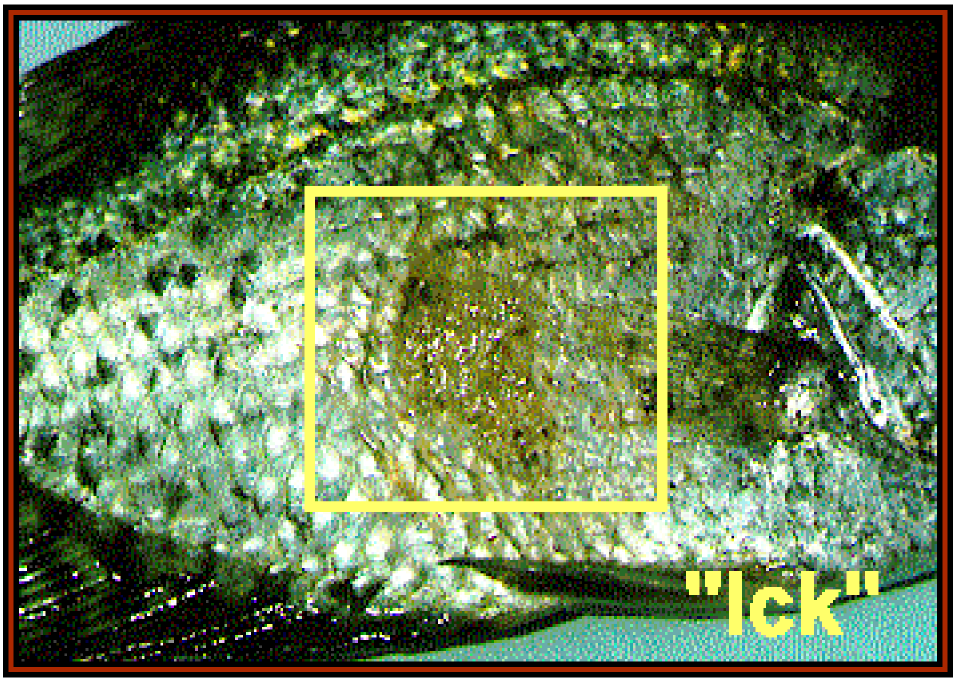
This parasite is found on many different species of fish under natural conditions, but it is a particularly serious parasite under conditions of confinement and high population density (i.e., aquaculture ponds, aquaria, etc.). There are a number of commercially available treatments for the parasite.



A trophozoite of *Ichthyophthirius multifiliis*. Such trophs measure up to 1 mm in diameter, and they contain a horseshoe-shaped macronucleus.

Trophozoites of *Ichthyophthirius multifiliis* in the gill tissue of a fish. (Original images from Oklahoma State University Parasitology Teaching Resources Web Site.

The next two images show the effects of "ick" on the skin and tail of two fish.




"Ick"

Graphic Images of Parasites

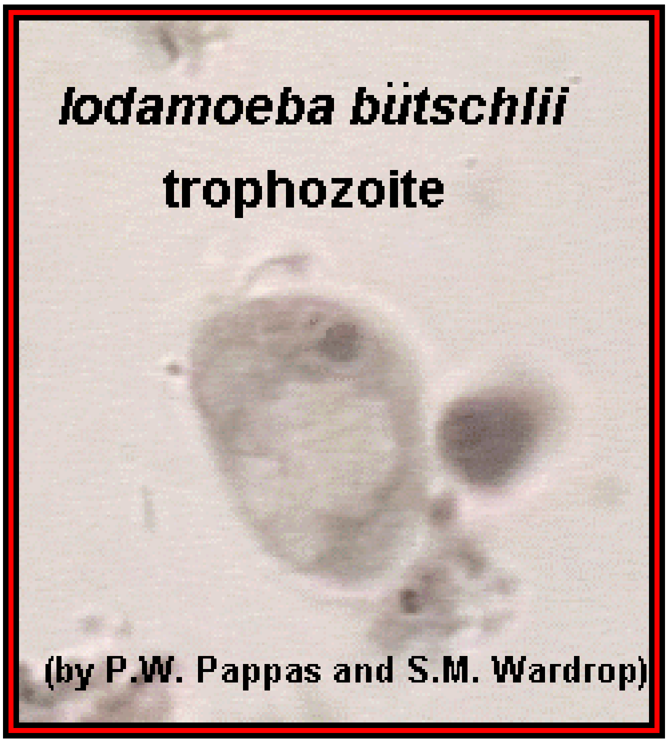
Iodamoeba bütschlii

(a commensal)

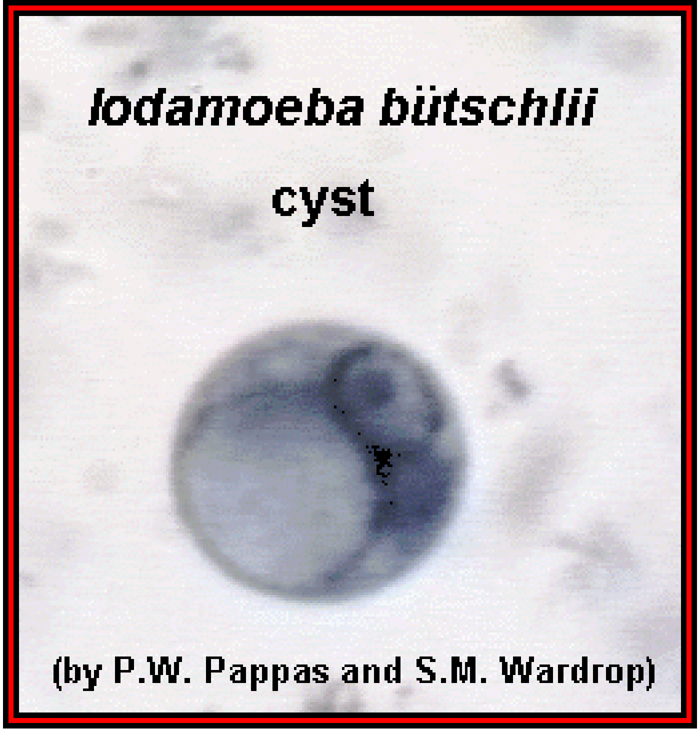
The life cycle of *Iodamoeba bütschlii* involves trophozoites that live in the host's large intestine and cysts that are passed in the host's feces. Humans are infected by ingesting cysts, most often in food or water contaminated with human fecal material. This species is considered to be a commensal (non-pathogenic). Nevertheless, it is important to differentiate this species from the pathogenic *Entamoeba histolytica* since it would be inappropriate to treat a person if they were not infected with a potential pathogen.

I. bütschlii is found in pigs as well as humans, and the infection can be transmitted from pigs to humans. Thus, the presence of this organism is of concern since it would indicate that the infected person might be infected with other organisms that are transmitted via food or water contaminated with fecal material.

This trophozoite of this species can be differentiated from *Entamoeba histolytica* and *Entamoeba coli* based on its appearance of its nucleus (a large endosome with little chromatin on the nuclear membrane). The cysts of *I. bütschlii* characteristically contain a large glycogen vacuole that makes it easy to distinguish from other species.



Iodamoeba bütschlii trophozoite. The single nucleus with its large endosome can be seen. This specimen is somewhat unusual in that it has a large glycogen vacuole. The nuclear membrane can not be seen since there is little chromatin associated with it; approximate size = 15 µm.



Iodamoeba bütschlii cyst; note the large glycogen vacuole that appears clear; approximate size = 15 µm.

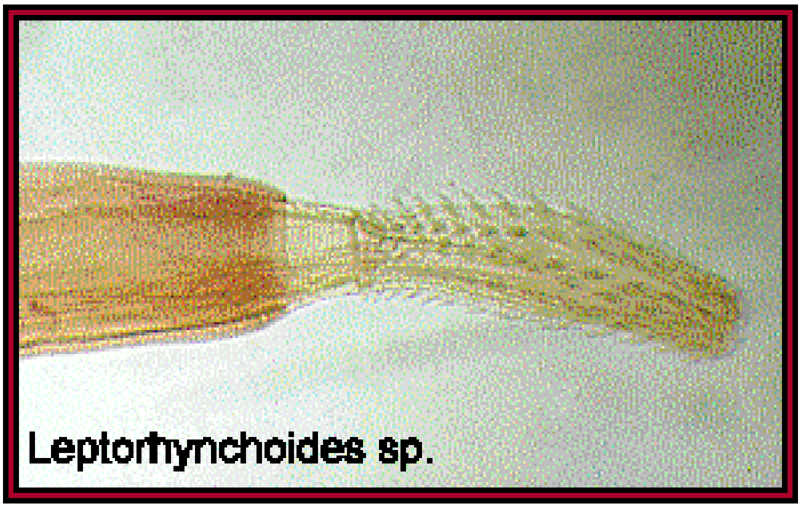
Isospora belli

Isospora belli is found in humans rarely, with infections being confined mainly to tropic regions. The biology of this parasite is similar to other species of Apicomplexa causing coccidiosis. The infection can cause various gastrointestinal upsets including nausea, pain, and chronic diarrhea. Like other coccidia, the infection is self-limiting, except in those individuals with compromised immune systems.

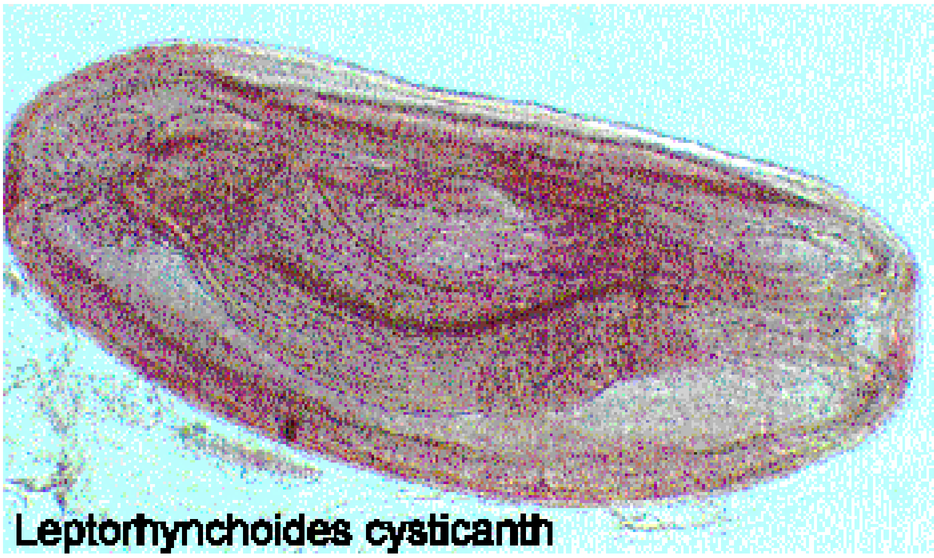
A sporulated oocyst of *Isospora belli*. (Image provided by Rodrigo Alves da Fonseca, Universidade de Brasilia, Departmento de Patologia.)

Leptorhynchoides sp.

As adults, members of this genus are parasites of the intestinal tracts of fish.



The anterior end of a specimen of *Leptorhynchoides* sp. showing the armed proboscis.

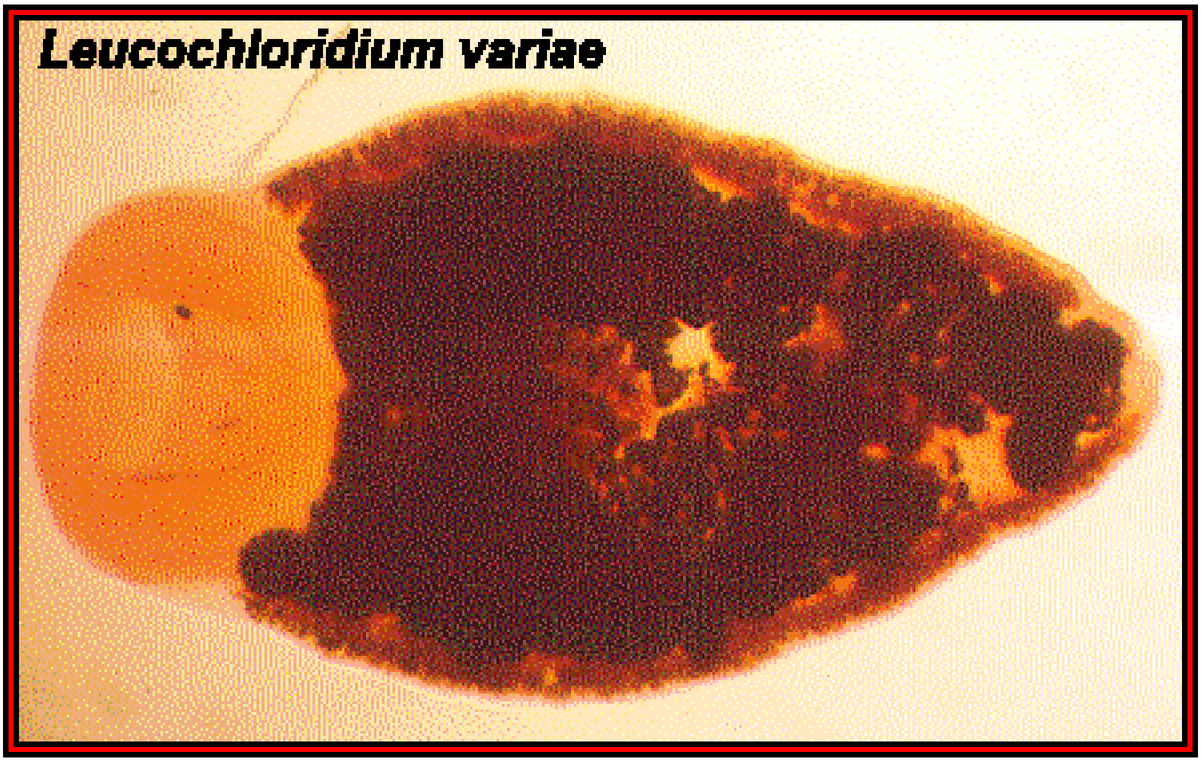


A cystacanth of *Leptorhynchoides* sp. This is the stage that would be found in the intermediate host and be infective to the definitive host.

Leucochloridium sp.

This genus contains *L. macrostoma*, a digenetic trematode that, because of its life cycle, is of particular interest to evolutionary biologists. Unlike most other digenetic trematodes whose life cycles require two intermediate hosts, this species requires only a first intermediate host. In the first intermediate host (a terrestrial snail or slug), sporocysts develop, and the sporocysts contain cercariae. The sporocyst, and cercariae within, are ingested when a definitive host (a bird) eats the snail or slug, and the cercariae develop into adult worms. Having to rely on one less intermediate host is certainly a selective advantage.

L. macrostoma has another interesting adaptation. In the intermediate host, the sporocysts develop in the host's tentacles (eye stalks). The sporocysts are colored brightly, and they pulsate continually. It is believed that this makes the snails or slugs more visible to the definitive host and, therefore, more likely to be eaten. It is not difficult to see how this would be advantageous to the parasite. The acanthocephalan, *Polymorphus minutus*, utilizes a somewhat different strategy to increase the probability of transmission.

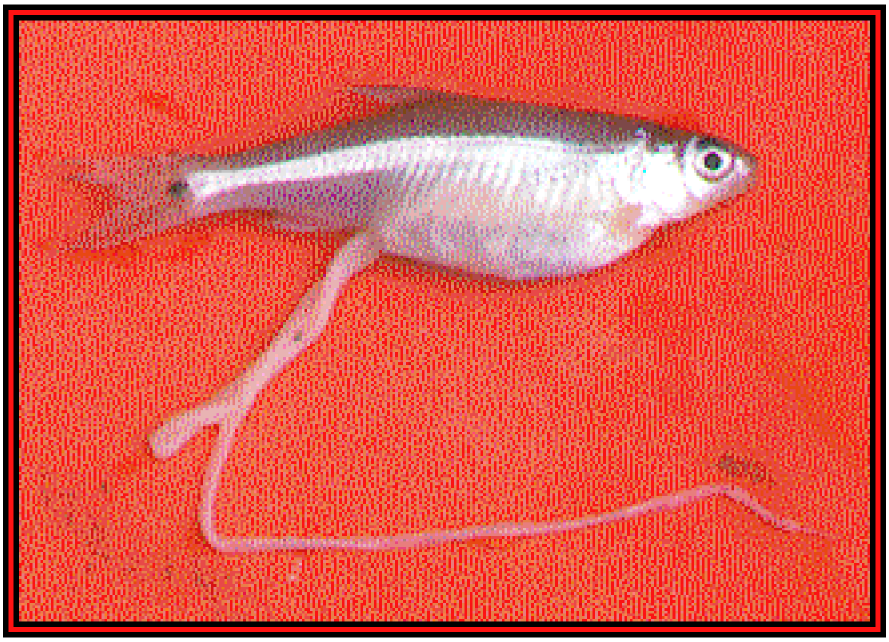


A stained whole mount of *Leucochloridium variae*. Although many of the internal organs are not visible, the large oral sucker, characteristic of this genus, is visible.

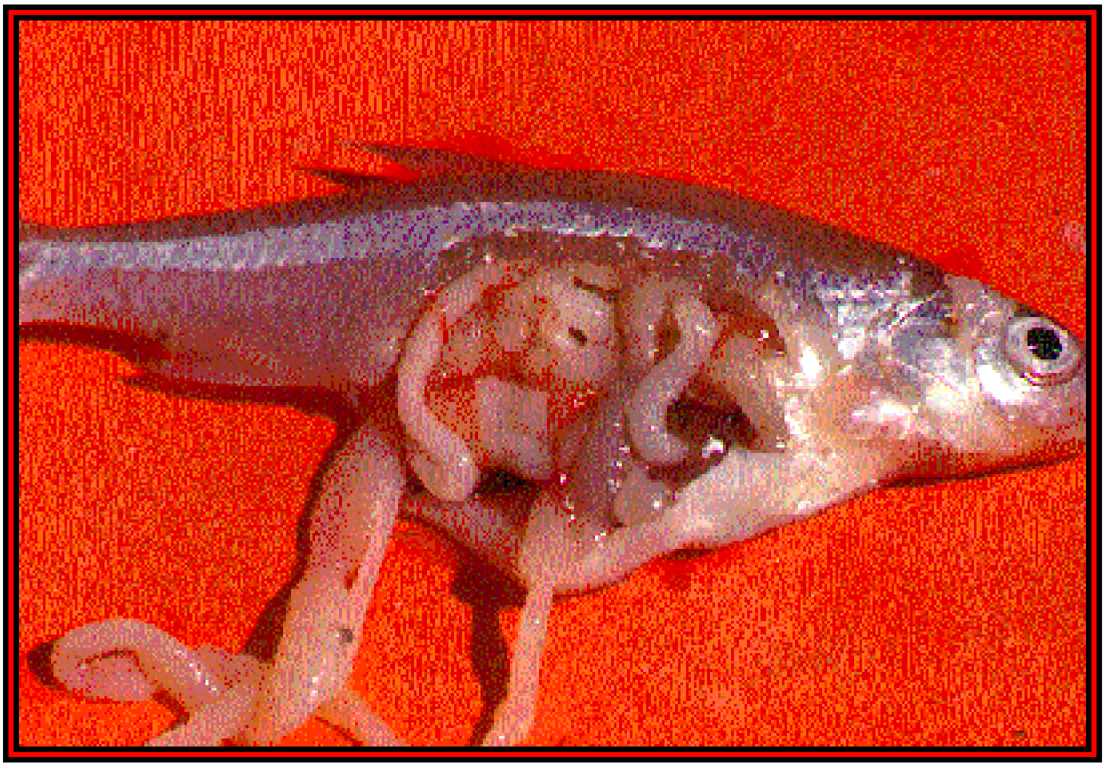
Graphic Images of Parasites

Ligula intestinalis

The life cycle of this parasite involves several species of birds as the definitive host, crustaceans as the first intermediate host, and fresh water fish as the second intermediate host. It is much more common to find fish infected with plerocercoids than it is to find birds infected with adults. This is because in the definitive host the parasite lives just long enough to reach sexual maturity and produce eggs, and then it dies.



Ligula intestinalis plerocercoid escaping from the peritoneal cavity of a spot-tailed shiner.

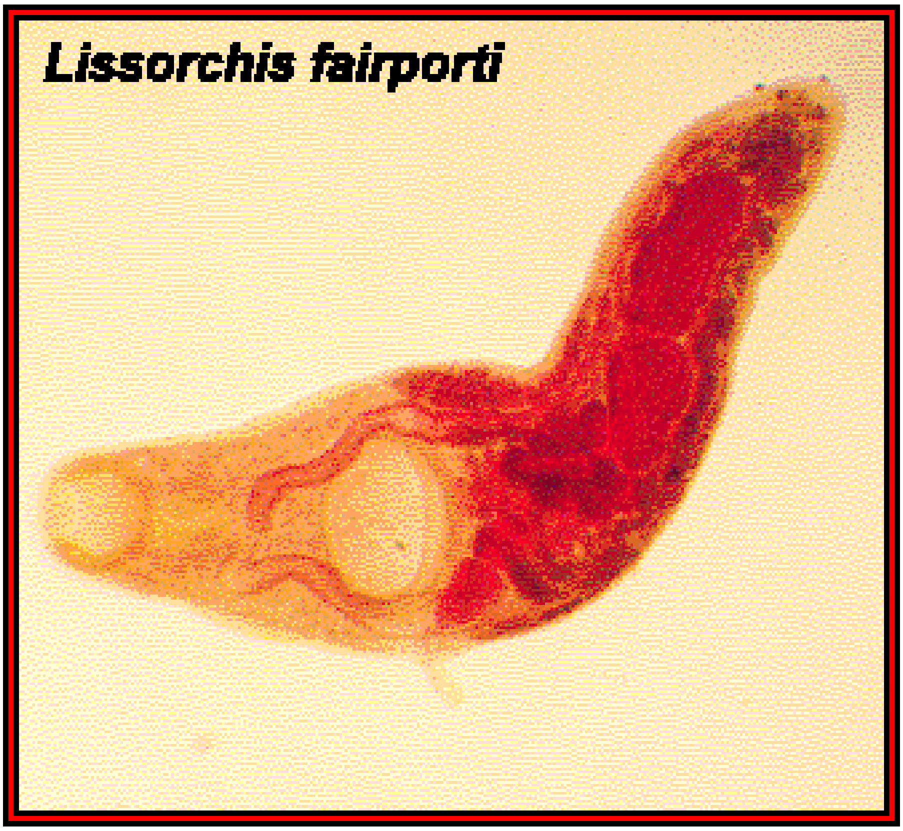


A spot-tailed shiner infected with *Ligula intestinalis* plerocercoids.

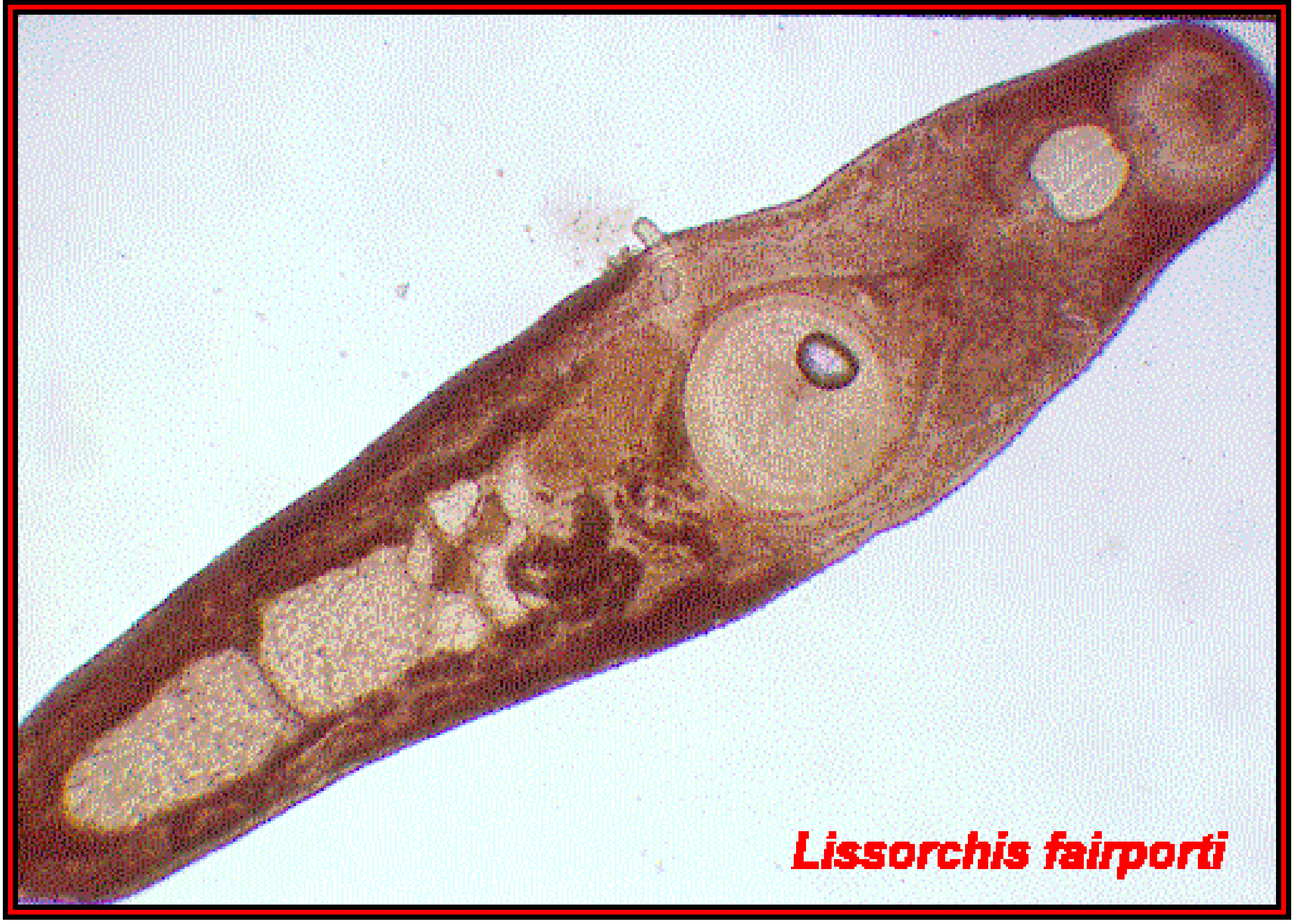
Graphic Images of Parasites

Lissorchis fairporti

This species parasitizes the intestines of fish. The first intermediate host is a snail (*Helisoma trivolvis*), and the second intermediate host is a chironomid larva.



A stained whole mount of *Lissorchis fairporti*, recovered from a carpsucker.

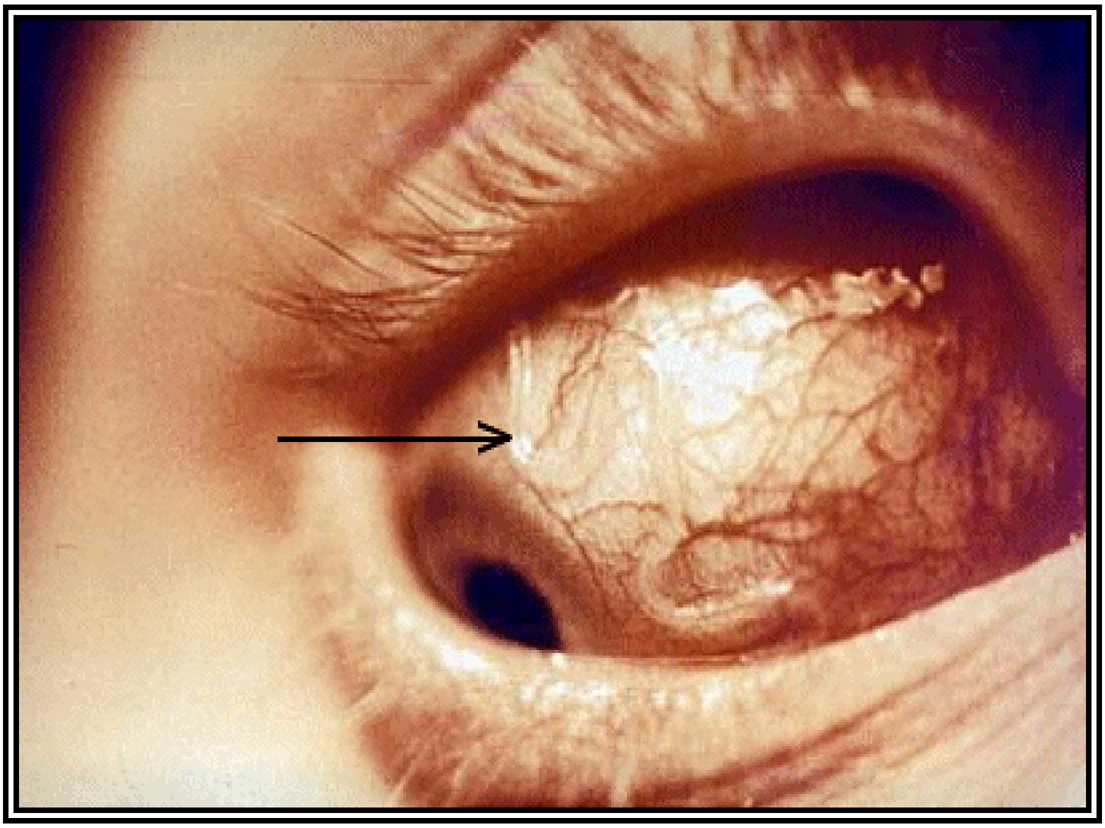


A living specimen of *Lissorchis fairporti* photographed with transmitted light. Even in this living specimen, many of the internal organs are visible.

Graphic Images of Parasites

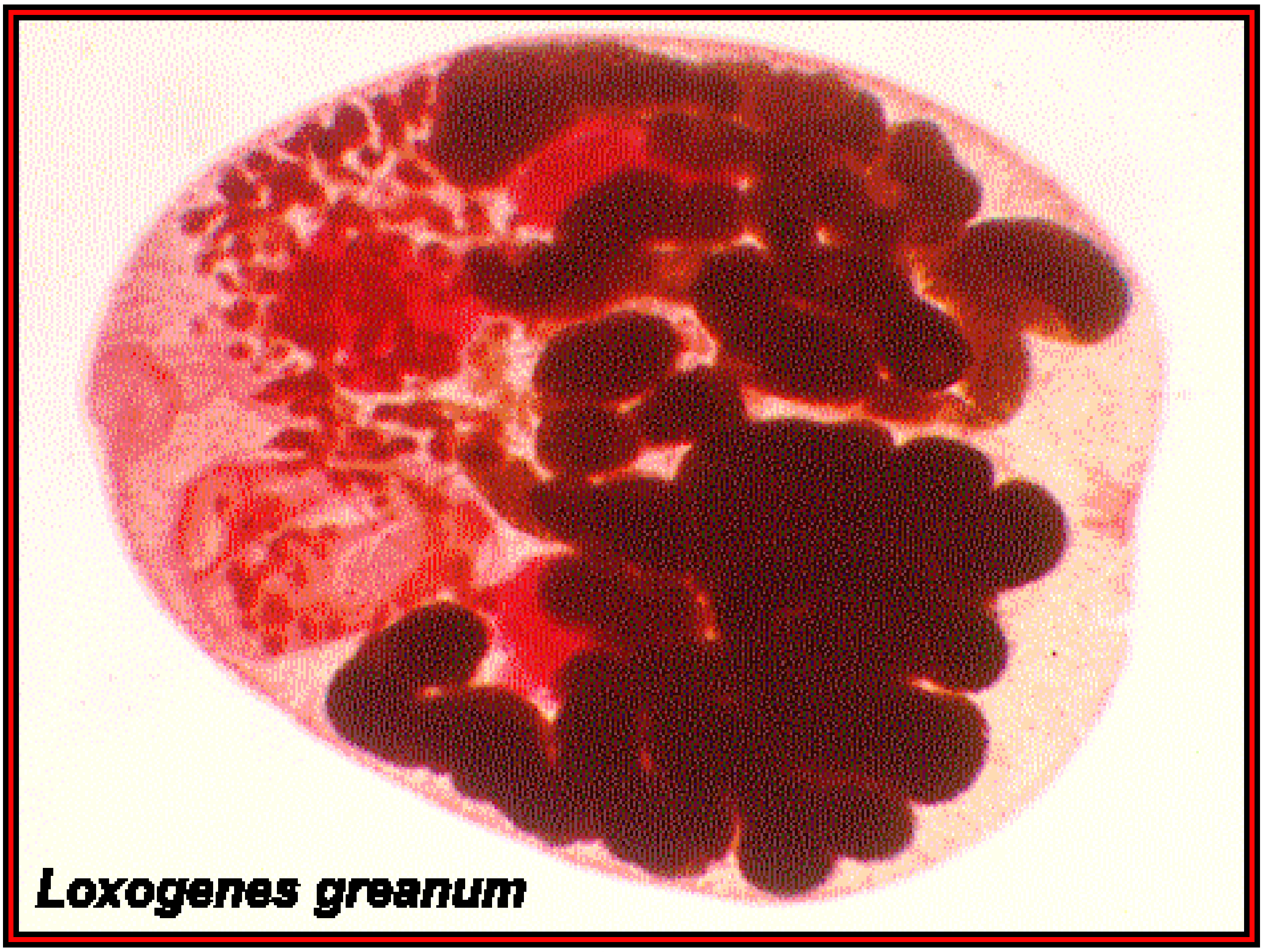
Loa loa

Although often refereed to as the "eye worm," *Loa loa* adults can be found in subcutaneous tissues in any part of the body, as well as in the conjunctiva of the eye. The female produces microfilaria, and the vector for the disease is a fly of the genus *Chrysops* (view diagram of the life cycle). The adult worms, which can measure 40-70 mm in length, can migrate through the subcutaneous tissues causing inflammation, and if the adults stay in one place for an extended period of time they can provoke a noticeable swelling, often called a "Calabar swelling." This species is confined to parts of equatorial Africa (view geographic distribution).



Loa loa in the eye (arrow). (Modified from an original image taken from the "Parasitological Diagnostics Aids Page.")

Loxogenes sp.



A stained whole mount of an adult *Loxogenes greanum.*

Lutztrema sp.

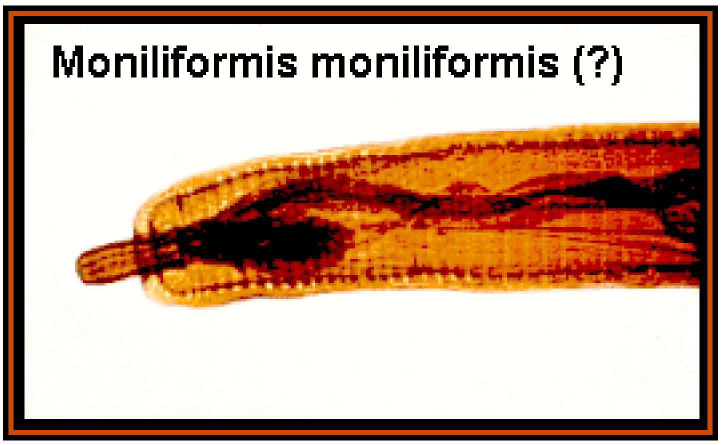
A stained whole mount of an adult *Lutztrema* sp. Note that the testes are anterior to the ovary, a characteristic of the family Dicrocoeliidae.

Macracanthorhynchus hirudinaecus

This species is a common parasite of pigs. Humans will also serve as the definitive host, but only a few such infections have been reported. (It is possible that many infections in humans go unreported.) The adult worms are found in the definitive host's small intestine. Female worms measure up to 60 cm long, while males generally do not exceed 10 cm. Such sexual dimorphism is common in the Acanthocephala.

Several species of beetles serve as the intermediate host for *M. hirudinaceus*. The beetles are infected when they ingest eggs passed in the definitive host's feces, and the definitive host is infected when it ingests infected beetles.

An egg of *Macracanthorhynchus hirudinaceus*. The eggs of this species measure about 80µm in length. (Original images from Oklahoma State University, College of Veterinary Medicine.)



The anterior end of what appears to be an adult *Moniliformis moniliformis*, an acanthocephalan. Note the armed proboscis, which is characterteristic of all acanthocephalans, including *M. hirudinaceus*, and the annulated appearance of the external surface.

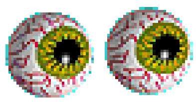
Graphic Images of Parasites

Plasmodium spp.
(malaria)

Malaria has been recognized as an important parasitic disease of humans for centuries, having been described by the early Egyptians in the third millennium B.C. Despite the introduction of control programs in many parts of the world over the past few decades, the impact of malaria on human populations continues to increase. Recent estimates suggest (1) that 1.5 billion persons live in areas of the world where malaria is an endemic disease, (2) that the number of infected humans exceeds 500,000,000, and (3) that 1-2 million persons die each year.

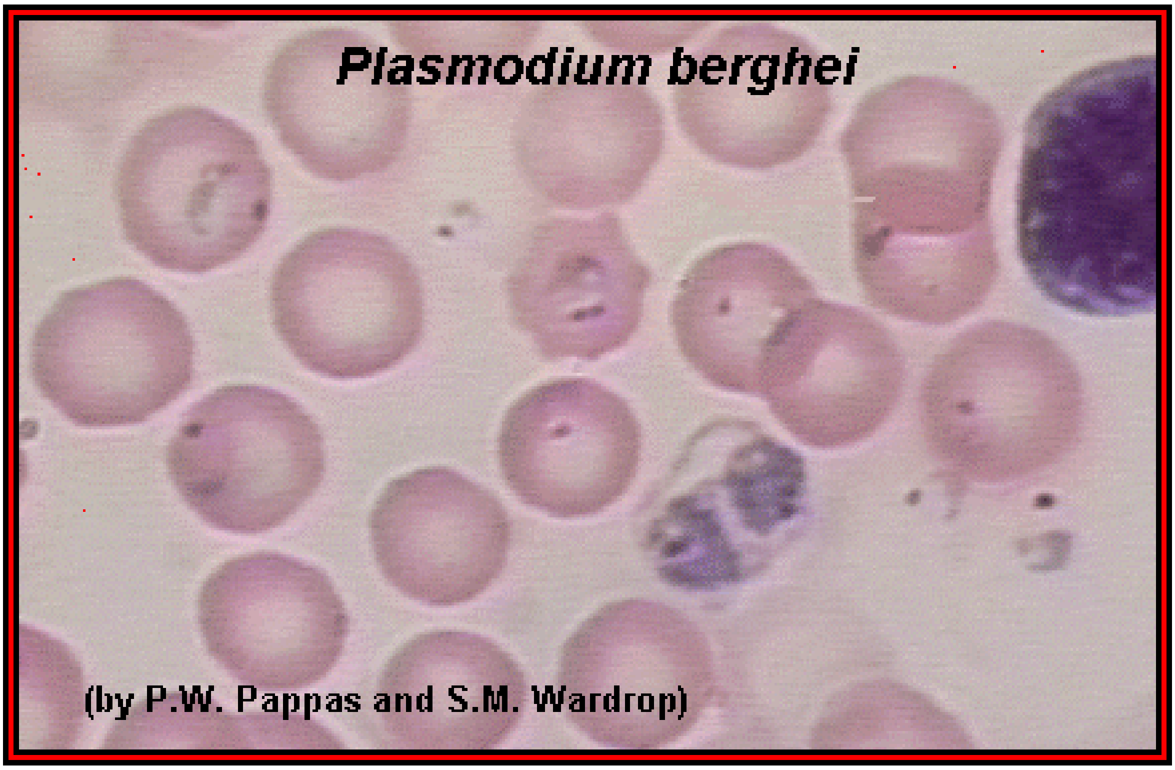
Four species of *Plasmodium* infect humans and cause malaria. All species are vector borne diseases, being spread by anopheline mosquitoes, and the disease is distributed throughout much of the world (view distribution). In the human host the parasite is found primarily inside of the red blood cells (RBC). The parasite reproduces asexually inside of the RBC, and following this the RBC breaks open releasing many new parasites (merozoites). These parasites then infect more RBC's, and this ultimately leads to the destruction of massive numbers of RBC's. The characteristic "chill and fever" (paroxysm) associated with malaria occurs when the parasites are released from the RBC's, and since the release of parasites is periodic, the paroxysms are periodic. For examples, the paroxysms associated with a tertian malaria (e.g., *Plasmodium vivax*) occur about ever 48 hours, and those associated with a quarten malaria (e.g., *Plasmodium malariae*) occur about every 72 hours (view a diagram of the life cycle).

The purpose of the images that follow is simply to depict some of the representative life cycle stages. If you are interested in information that can be used to differentiate the four species of *Plasmodium* that infect humans, click here.

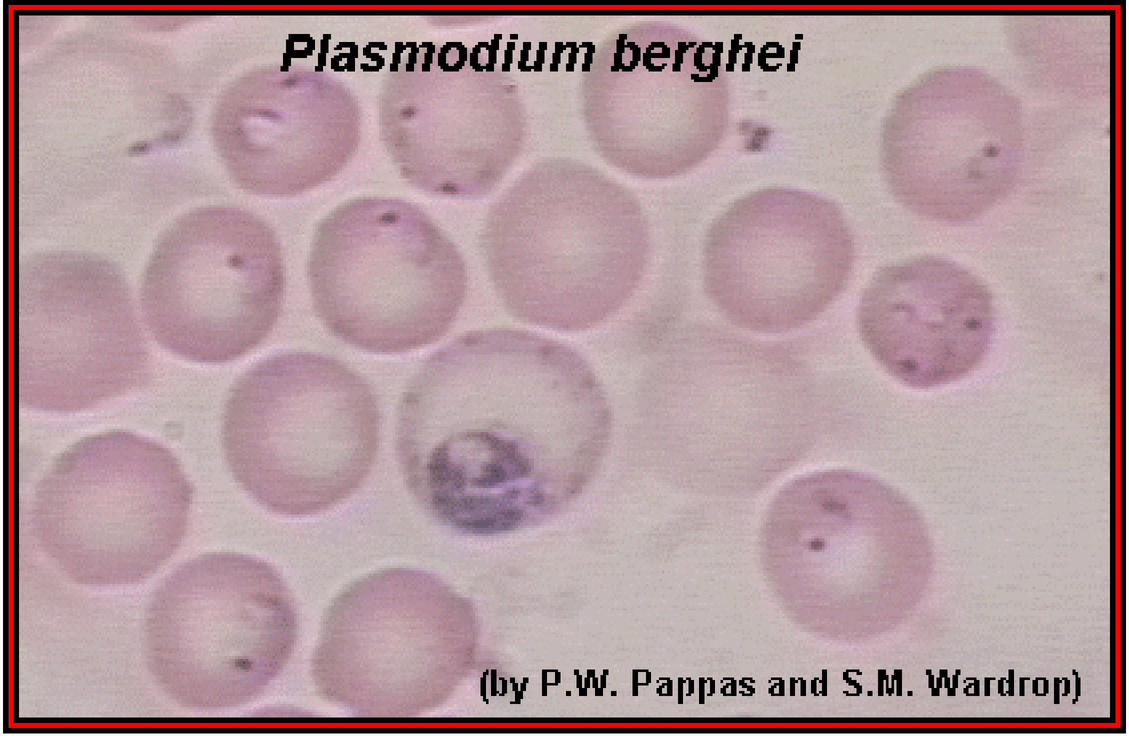


Click here to view images of the four species of *Plasmodium* infecting humans.

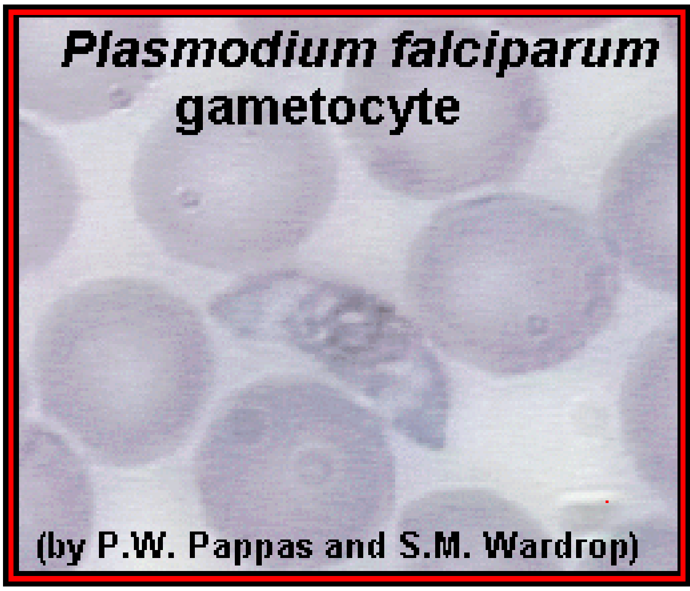
Sporozoites of *Plasmodium*; approximate length of each = 10 µm. This life cycle stage is produced by the oocyst (see below), migrates to the mosquito's salivary glands, and is injected when the mosquito feeds.

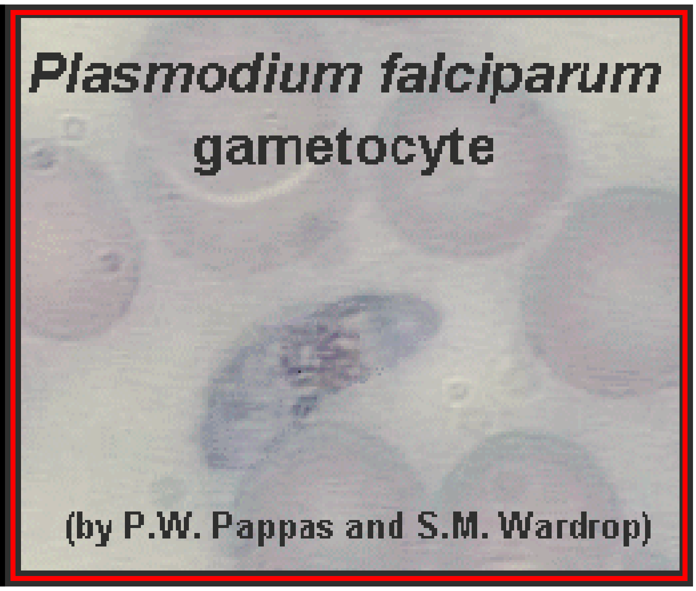


Plasmodium berghei rings and trophozoites in the blood of an experimentally infected mouse. This species does not infect humans, but it is used in many laboratories as a "model" for studying malaria in the vertebrate host.

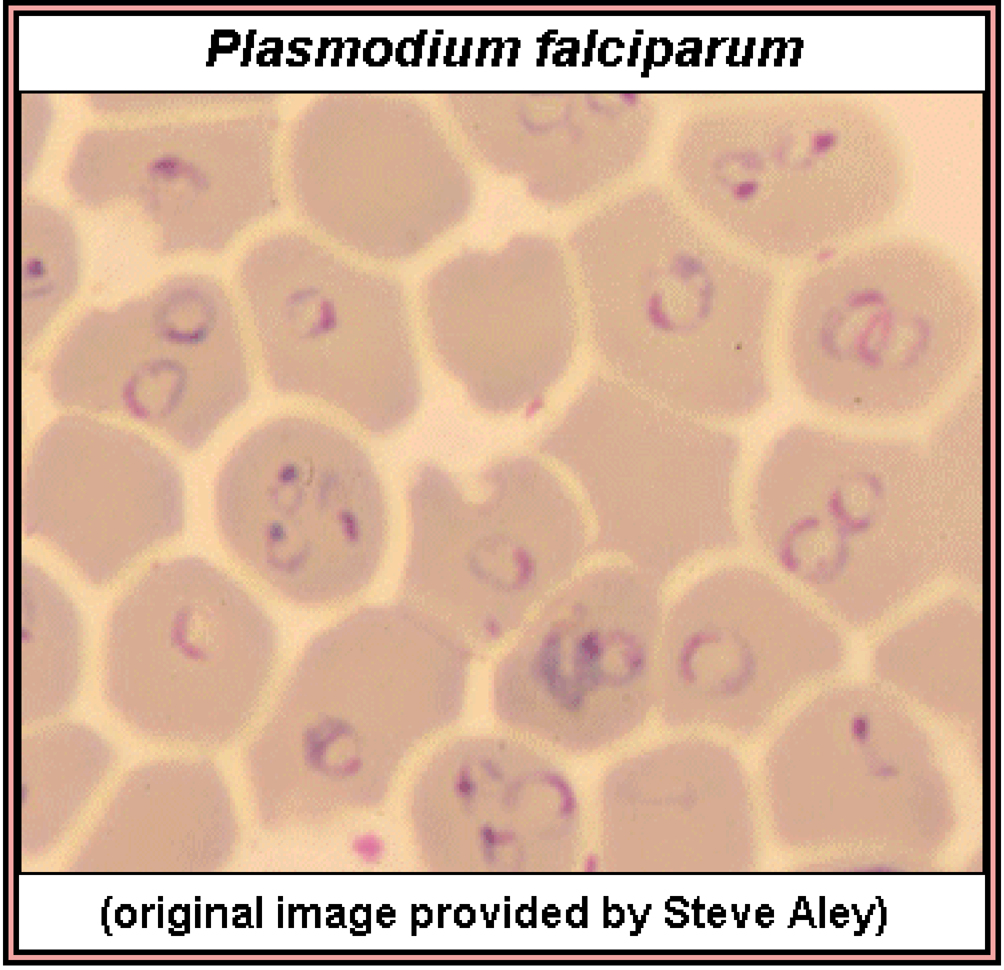


Plasmodium berghei rings and trophozoites in the blood of an experimentally infected mouse.

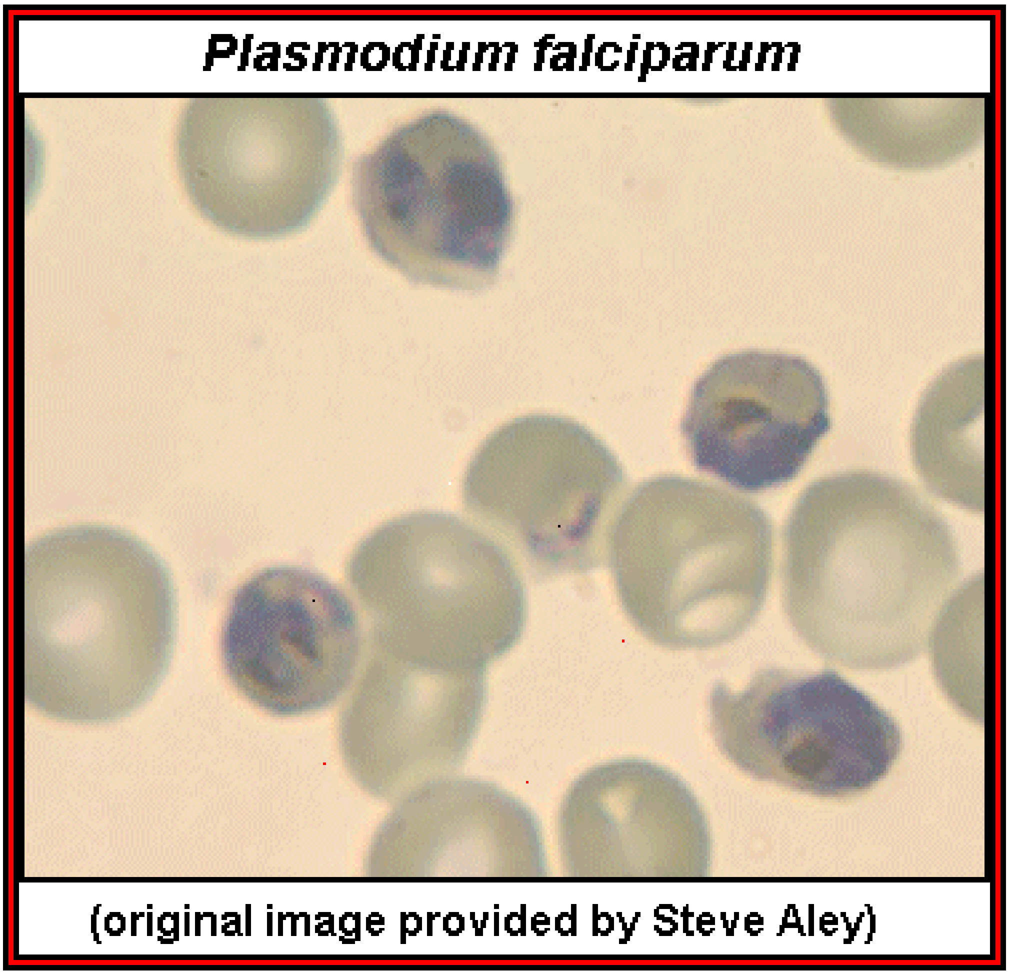




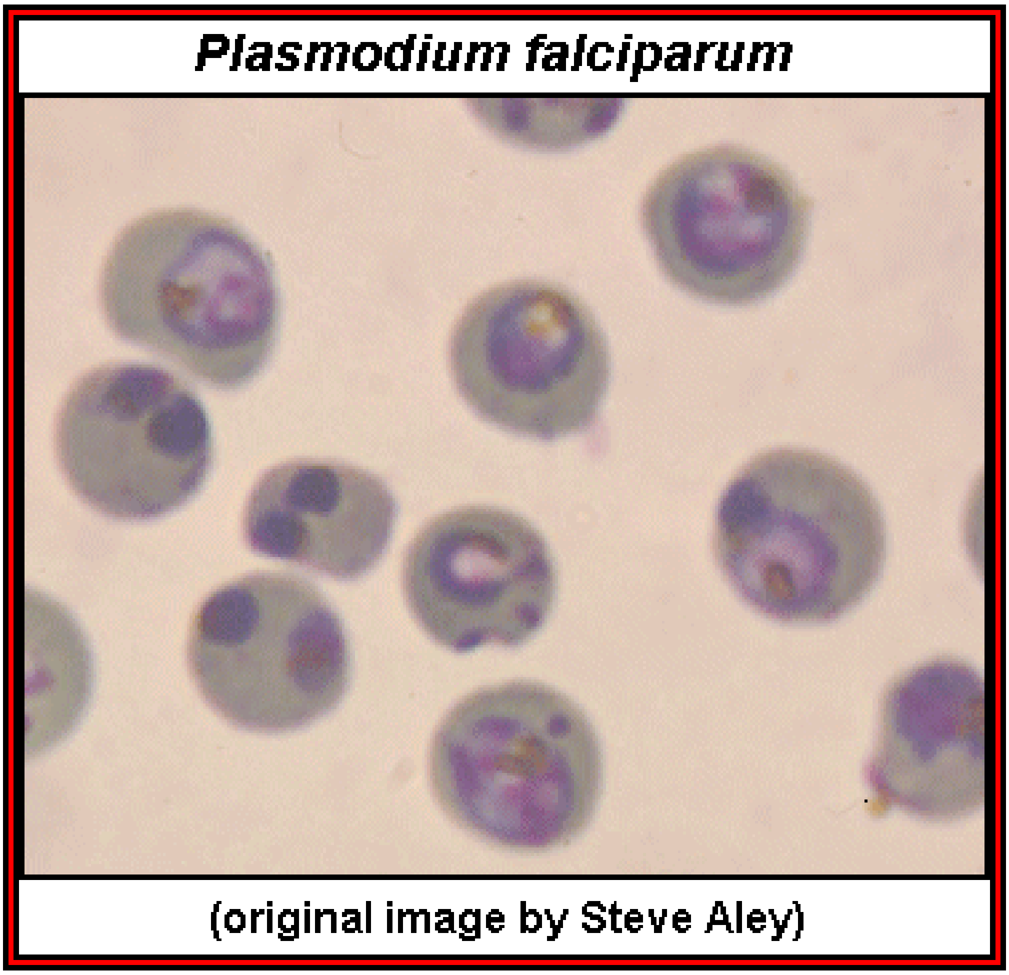
Gametocytes of *Plasmodium falciparum* in a blood smear. Note the characteristic shape.



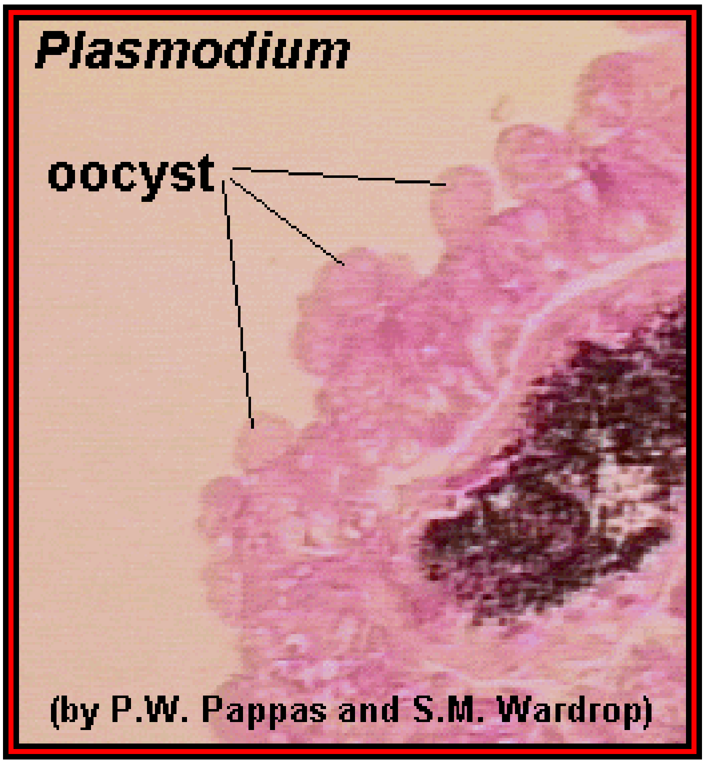
Ring stages of *Plasmodium falciparum*. Note the multiple infections of some cells.



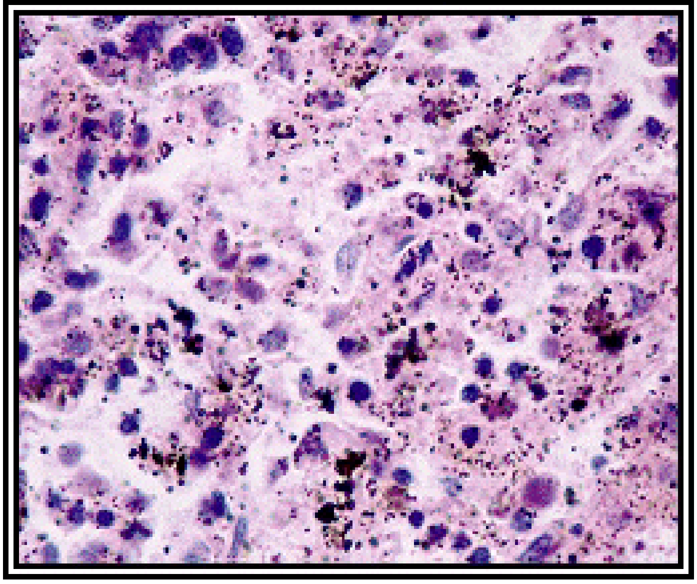
Trophozoites (late ring stages) of *Plasmodium falciparum*.



Plasmodium falciparum trophs and early schizonts.



Oocysts of *Plasmodium* on the surface of a mosquito gut. The dark material is partially digested blood inside of the mosquito gut.



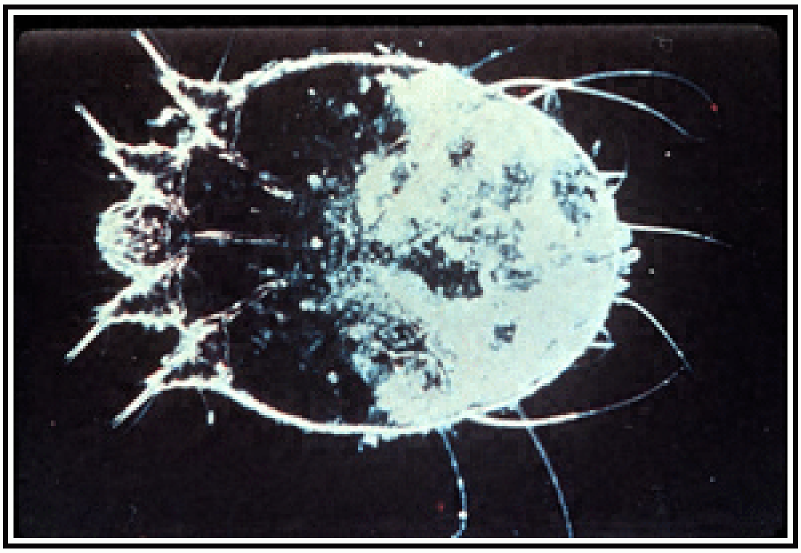
Hemozoin (digested hemoglobin) deposited in the cells of the spleen in a human infected with malaria. (Original image from "Parasites in Human Tissues," Department of Parasitology, Kyungpook National University School of Medicine, Korea.)

Sarcoptes scabiei
(scabies, sarcoptic mange)

Itch or mange mites have been described from a variety of animals, but it is unclear if the mites from different animals represent different species. While some mites seem to show a predilection for one species of host, the host specificity does not appear to be absolute.

Transmission of mites between humans is by physical contact. Male and female itch mites mate on the skin, and it is the female that borrows into the skin and causes problems. She borrows into the skin, and can live as long as two months, and the excretory and secretory products that she produces result in an intense itching followed in many instances by a rash. A possible complication is a secondary infection that results from scratching the rash.

Sarcoptic mange in animals is similar to that in humans. The symptoms of mange in animals include weight and hair loss, and dermatitis. Horses, dairy cattle, pigs, and dogs are all susceptible to sarcoptic mange. Mange in cats (and dogs occasionally) is caused by a similar mite, *Notoedres cati*. Notoedric mange usually begins at the tip of the animal's ears (causing an ear kanker), and it may affect the entire head and spread to the rest of the body.



Sarcoptes scabiei, the scabies or itch mite. (Original image from Identification and Diagnosis of Parasites of Public Health Concern)

Another image of a scabies mite. (Original image from The Internet Pathology Laboratory for Medical Education

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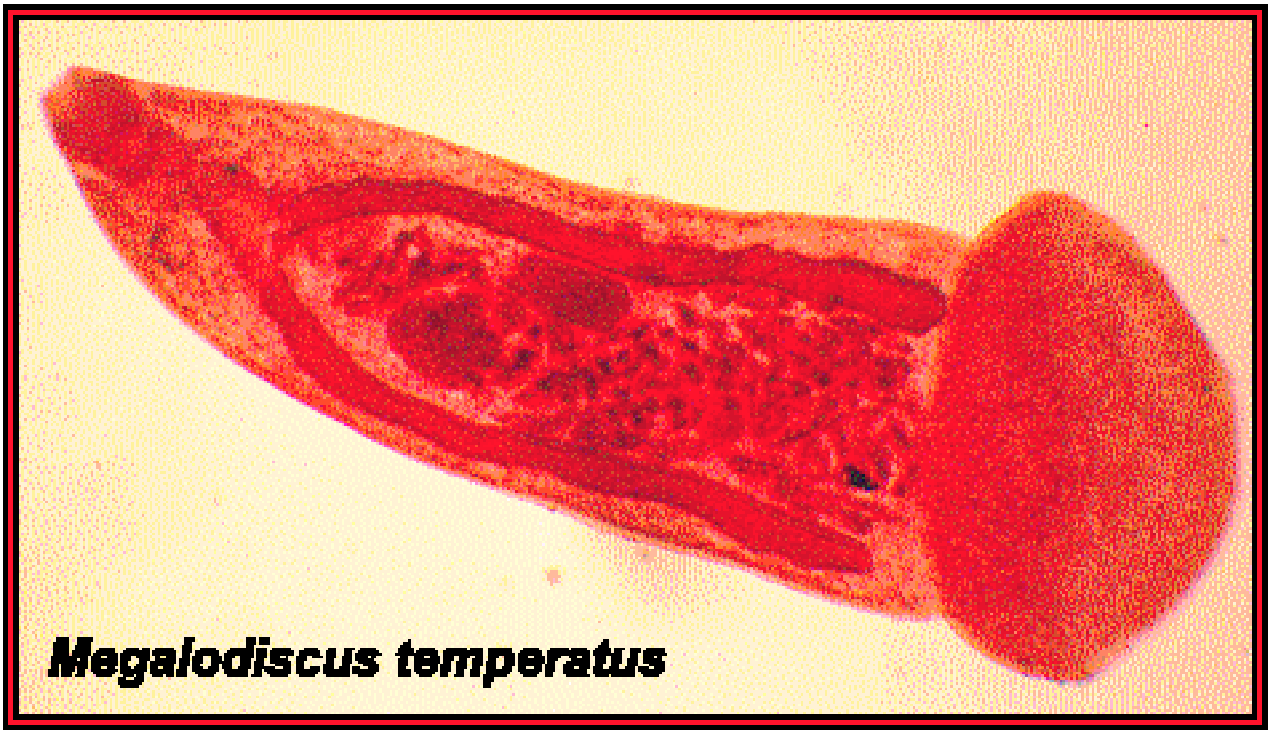
A severe case of scabies of the hand. (Original image from Identification and Diagnosis of Parasites of Public Health Concern)

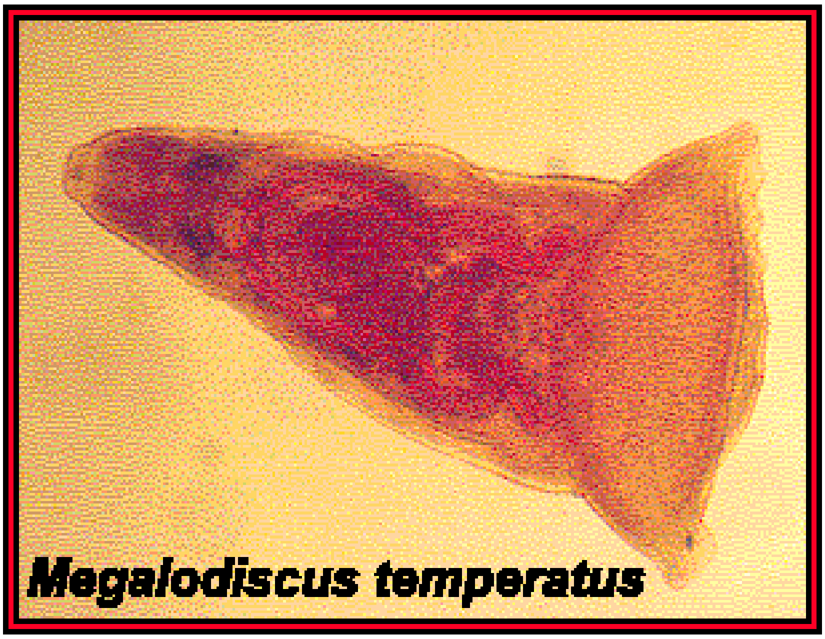
Sarcoptic mange on the legs of a dog. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

A pig with sarcoptic mange. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Megalodiscus temperatus

This species is found in the cloaca or rectum of the amphibian (frog) host. Eggs are passed in the feces, and several species of snails of the genus *Helisoma* will serve as the intermediate host. Cercariae are liberated from the snails and encyst on the skin of frogs or tadpoles. Frogs are infected when they ingest infected tadpoles, or when they eat their skin after molting.





The above images are stained whole mounts of *Megalodiscus temperatus* recovered from the cloaca of *Rana pipiens*. The large ventral sucker (acetabulum) located at the posterior end of the body, a characteristic of the family Paramphistomatidae, is clearly visible.

Mesocestoides sp.

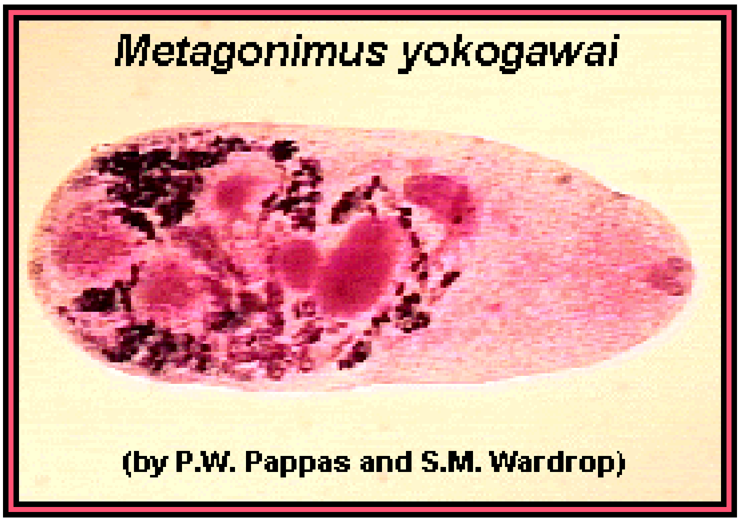
No complete life cycles are known for any members of this genus. Nevertheless, what little is known indicates some unusual aspects of development. The adult worms are found in the small intestines of carnivores. The adults reproduce sexually, but they may also reproduce asexually. In the latter case the scolex divides longitudinally and produces a second tapeworm. This is the only genus of tapeworms in which this phenomenon has been reported. The eggs are passed in the definitive host's feces and ingested by a first intermediate host --- the identity of this host has not been discovered for any species. The second intermediate host is generally a reptile or mammal, and the larval stage found in the second intermediate host is called a tetrathyridium. Like the adult tapeworm, the tetrathyridium can also reproduce asexually by longitudinal division. Because of these unusual characteristics, some authorities believe that members of this genus should be included in a separate order (rather than a separate family).

Tetrathyridia of *Mesocestoides* sp. (probably *M. corti*). This life cycle stage will reproduce asexually in the second intermediate host by longitudinal division.

Graphic Images of Parasites

Metagonimus yokogawai

Metagonimus yokogawai is similar to *Heterophyes heterophyes* is many respects. *M. yokogawai* is found in the small intestines of humans, dogs, cats, pigs, and rodents in parts of southeast Asia and the Balkans. The second intermediate host is a freshwater fish, and the definitive host is infected by ingesting fish infected with metacercariae (view diagram of the life cycle). The pathology associated with *M. yokogawai* is similar to that associated with *H. heterophyes*.



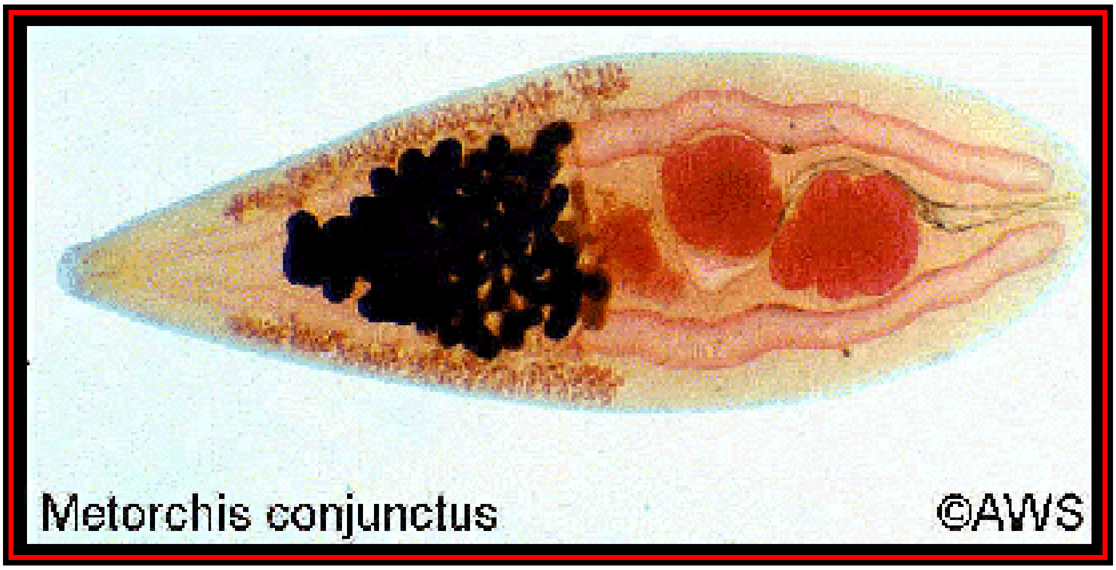
Metagonimus yokogawai, adult, whole mount; approximate size = 1.5 mm in length. Click here to view a second image in which the organs are labeled.

A *Metagonimus* egg. (Original image from a Japanese language site tentatively identified as the Internet Atlas of Human Parasitology.)

Graphic Images of Parasites

Metorchis conjunctus

This digenetic trematode is found in the livers of a number of vertebrates, including dogs, foxes, cats, raccoons, mink, and muskrats, and it has been reported rarely from humans. The life cycle is typical of digenetic trematodes. The eggs are produced by the adult parasites, passed in the host's feces, and ingested by a fresh water snail (e.g., *Amnicola limosa*). Cercariae are liberated from the snail and then penetrate and encyst in the muscles of fish. The definitive host is infected when it eats fish with metacercariae. In the host's small intestine the metacercariae excyst, and the immature worms simply migrate up the bile duct where they mature.

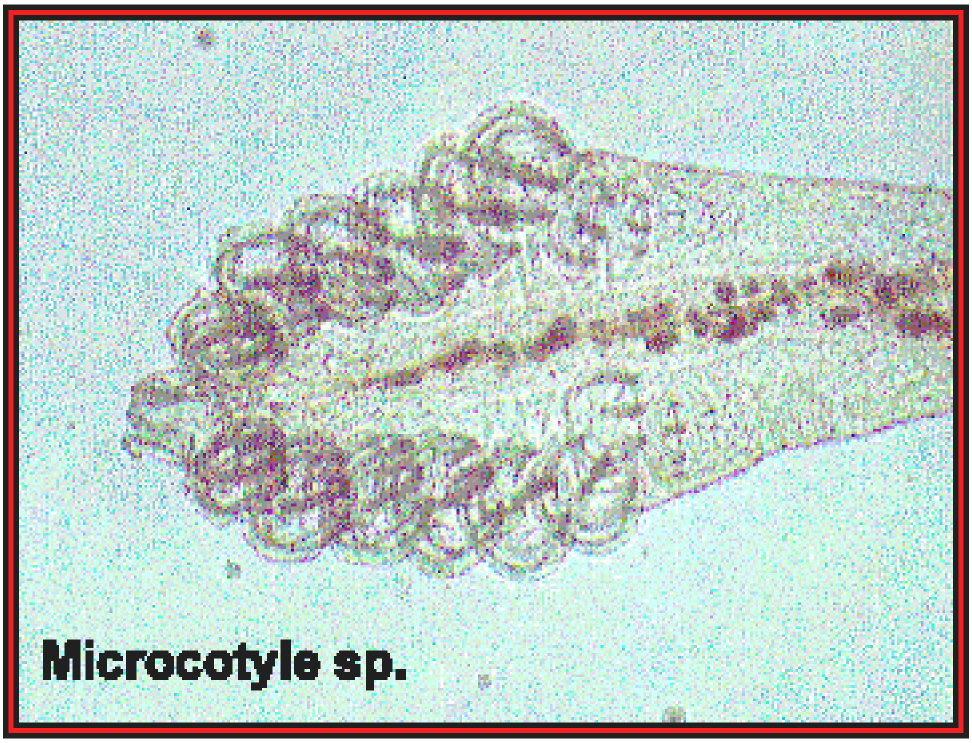


A whole mount of *Metorchis conjunctus*. Adults of this species can measure up to 6 mm in length. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

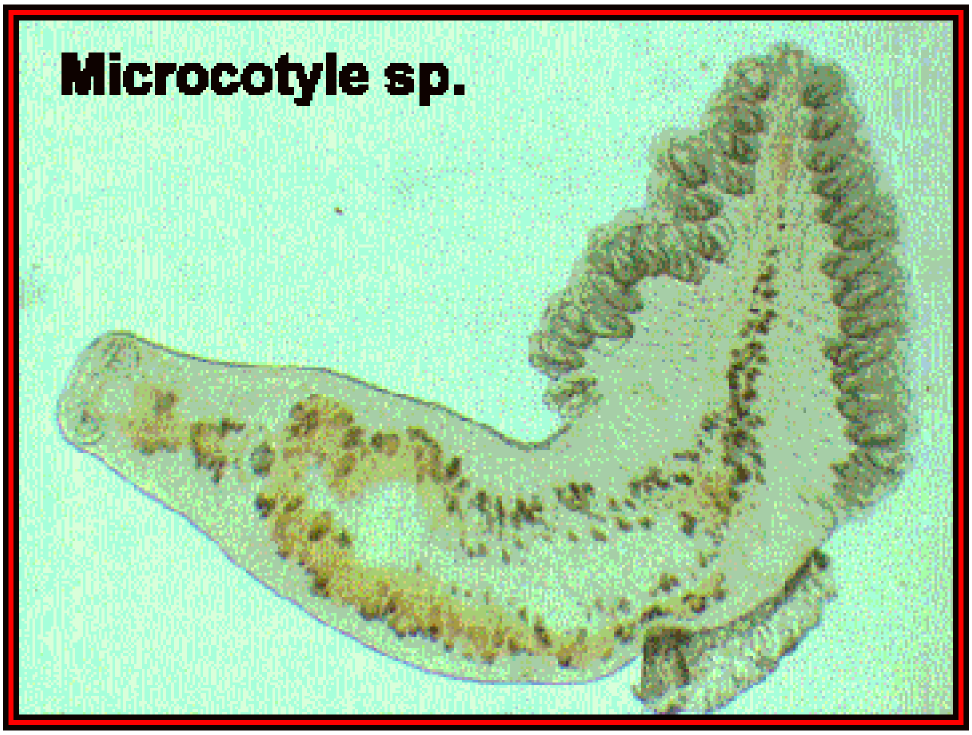
Graphic Images of Parasites

Microcotyle sp.

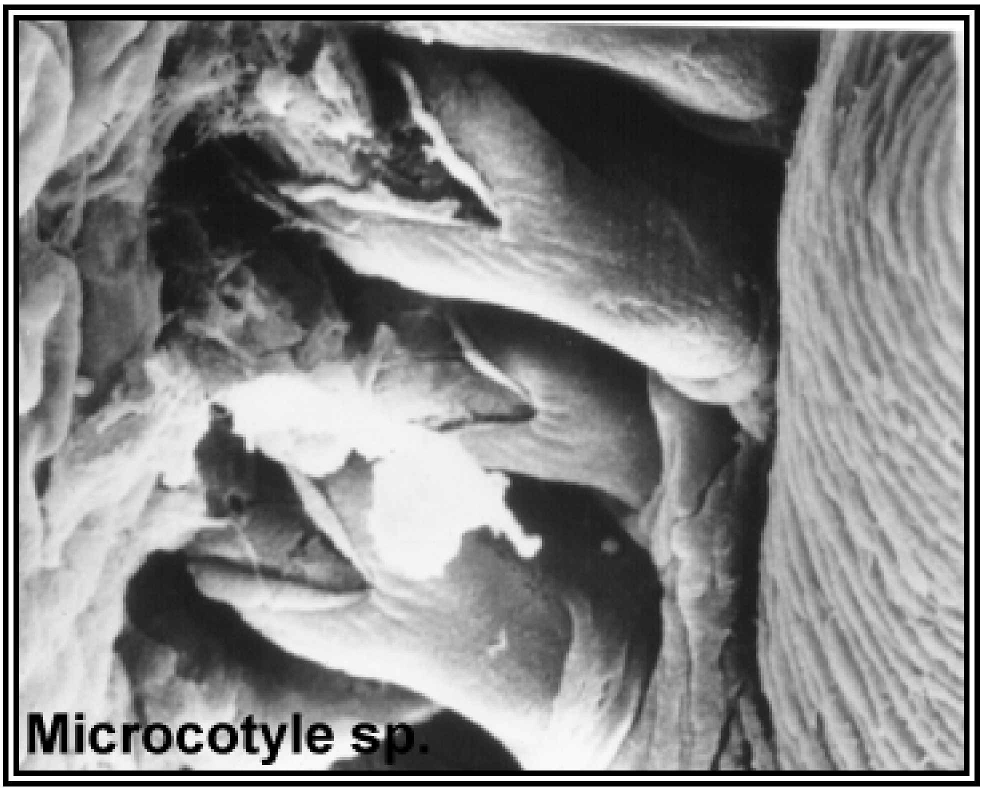
In members of this genus, the opisthaptor is divided into a number of "clamps." The "clamps" are sclerotized "pinching bars" adapted to attaching the parasite to the host's gills.



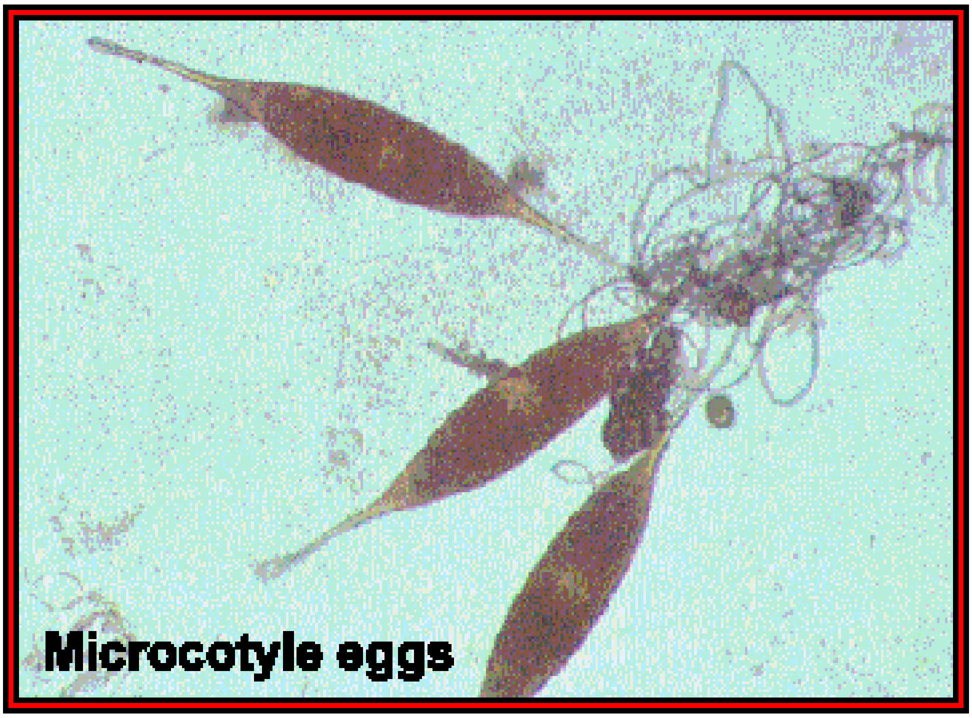
A stained whole mount of the opisthaptor of a young *Microcotyle*. The opisthaptor of this specimen contains 15 "clamps," and the number of "clamps" will increase as the parasite grows older (see below).



A stained whole mount of an adult *Microcotyle*. Note that the opisthaptor of this specimen has many more clamps than the above specimen.



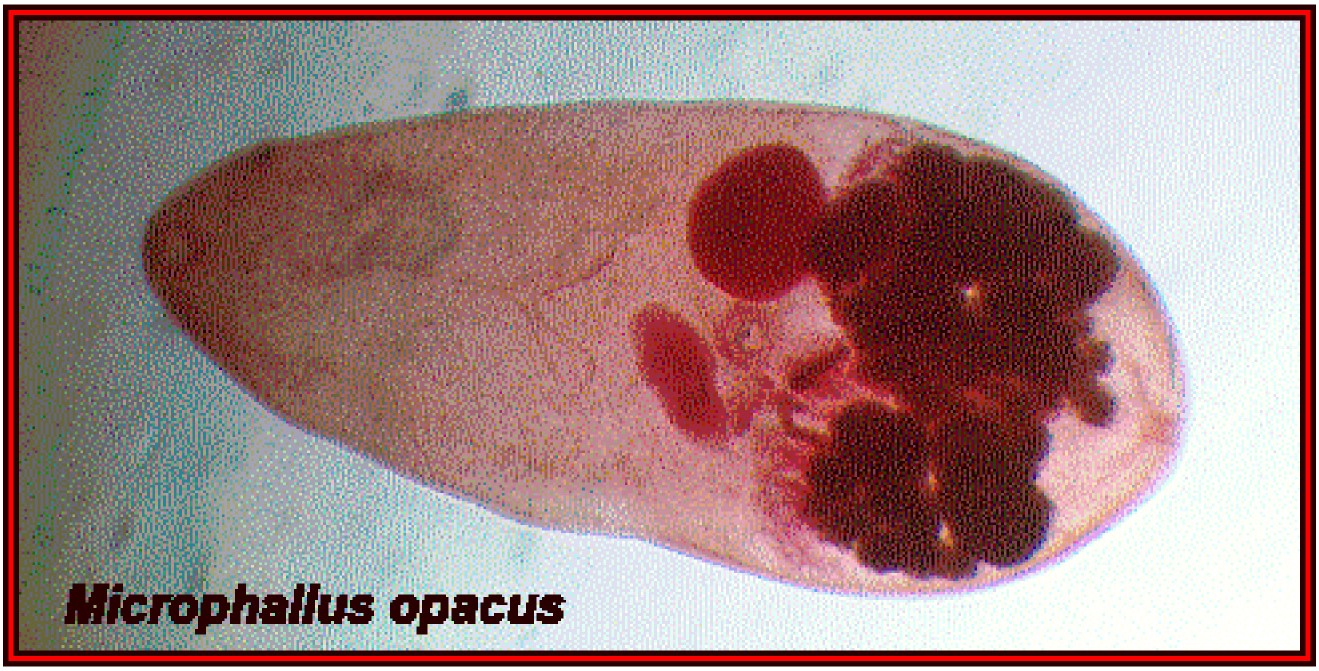
A scanning electron micrograph of the opisthaptor of a *Microcotyle* attached to the gills of its host. Notice the individual "clamps" (on the right) attached to the individual gill filaments (on the left).



Eggs of *Microcotyle* sp. As with most monogenea, the eggs have filaments.

Graphic Images of Parasites

Microphallus sp.

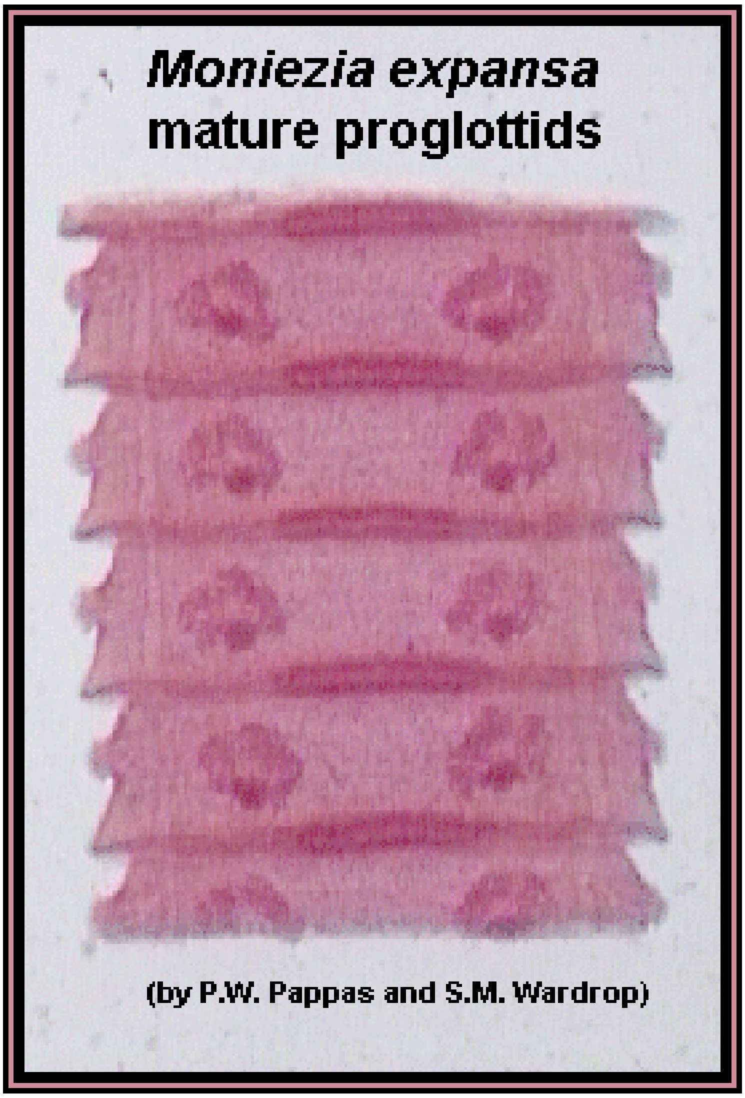


A stained whole mount of an adult *Microphallus opacus*.

Graphic Images of Parasites

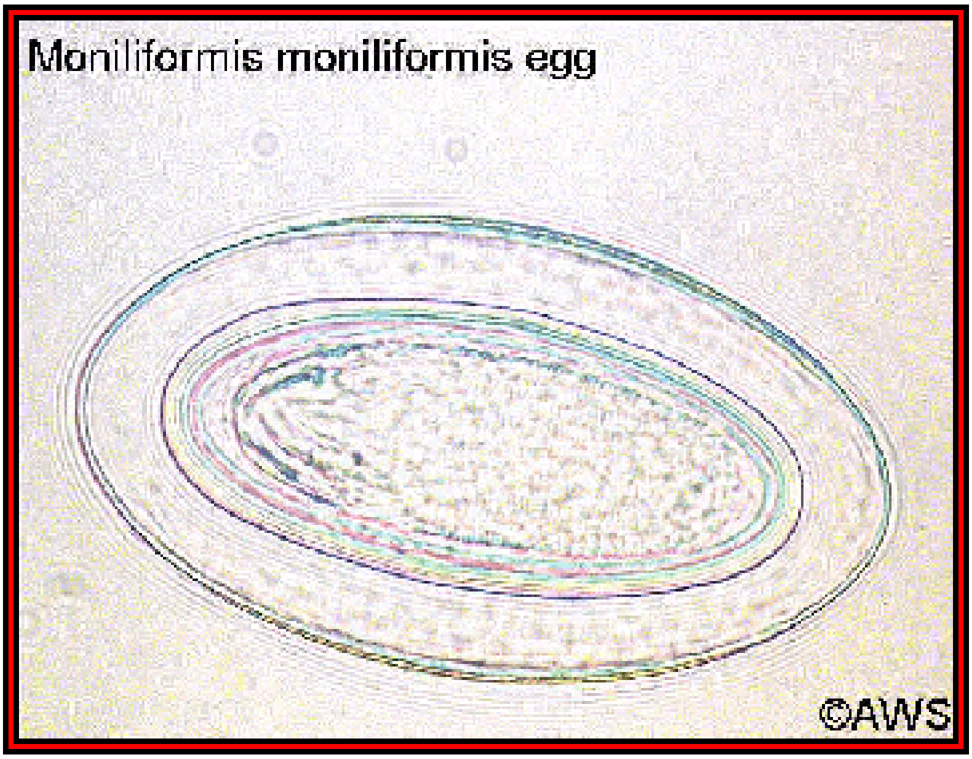
Moniezia expansa

The life cycle of *Moniezia expansa* involves sheep as the definitive host and soil mites as the intermediate host. The tapeworm's eggs are passed in the sheep's feces, and mites are infected when they eat the eggs; the metacestode stage in the mite is called a *cysticercoid*. Sheep are infected when then ingest infected mites (view diagram of the life cycle). This species of tapeworm is unusual in that each proglottid contains two sets of female reproductive organs (see *Dipylidium caninum*, also).

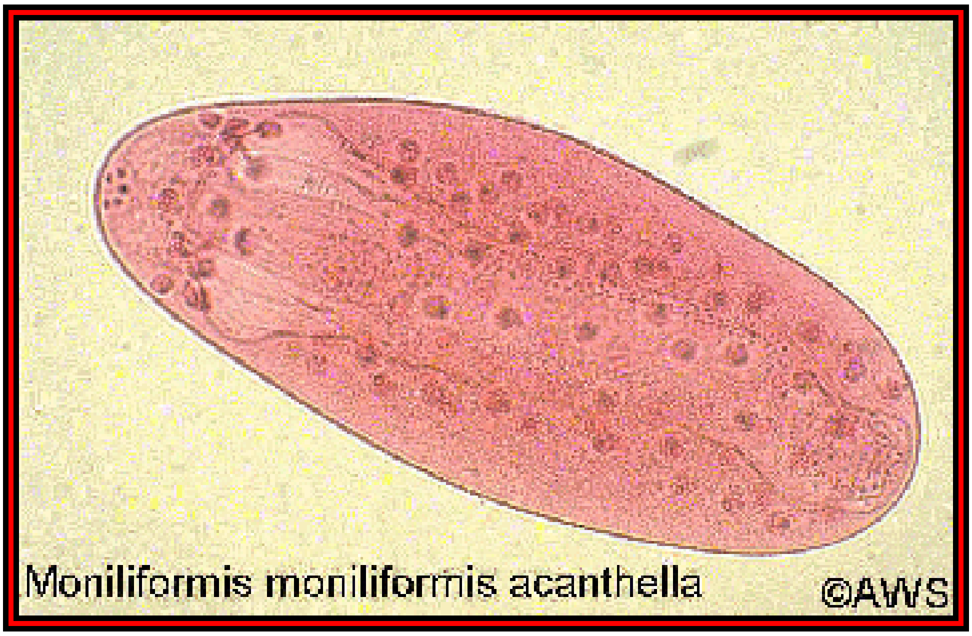


Mature proglottids of *Moniezia expansa*. The two sets of female reproductive organs are visible. Click here to view a second image in which the internal organs are labeled.

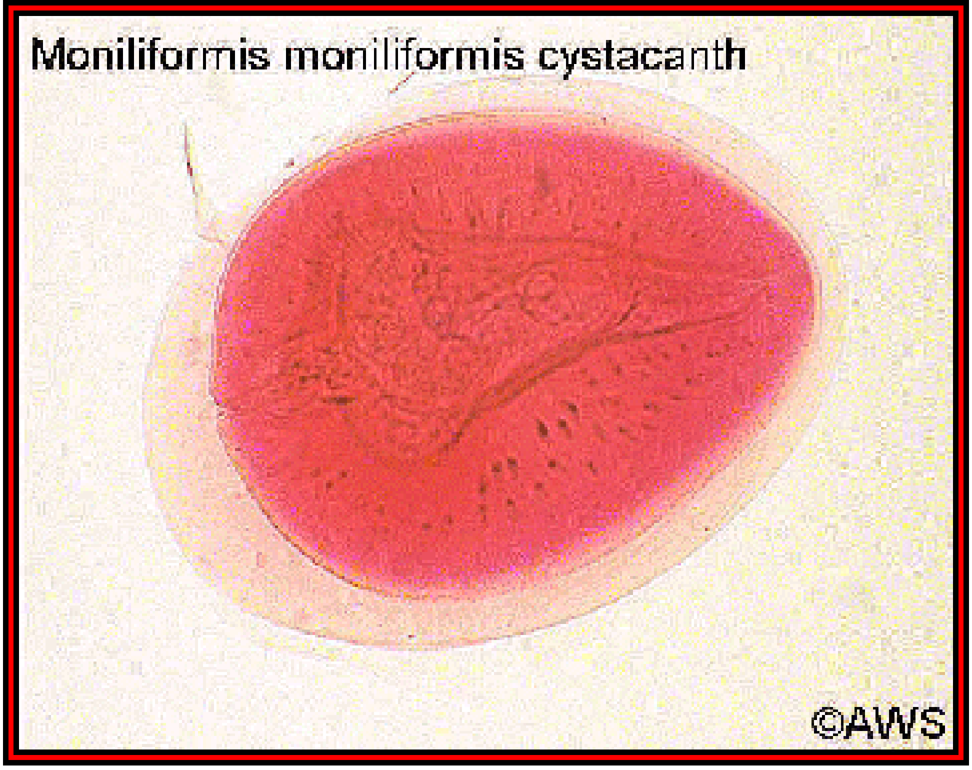
Moniliformis sp.



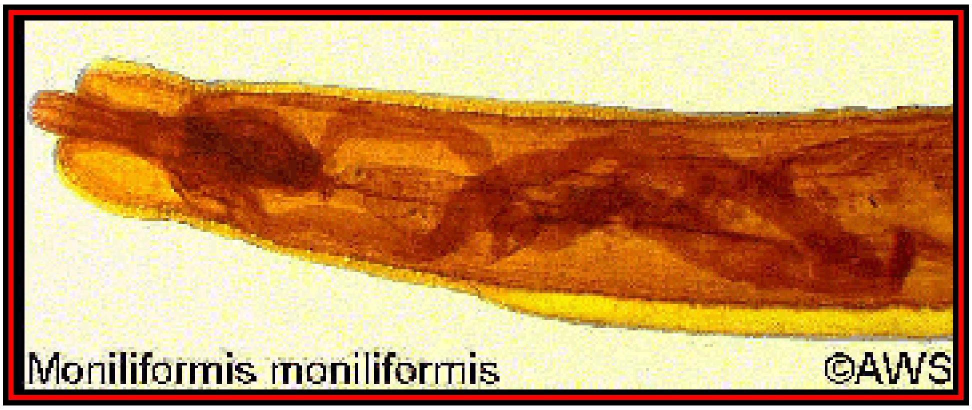
An egg of *Moniliformis moniliformis*. Eggs average about 45 x 100 µm. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.



An acanthella of *Moniliformis moniliformis*. This is an early stage of development that would be found in the intermediate host (a beetle or cockroach). Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.



A cystacanth of *Moniliformis moniliformis.* This stage would be found in the hemocoel of the intermediate host, and it is infective to the definitive host. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.



The anterior end of an adult *Moniliformis moniliformis*. The proboscis is visible on the left side of the image. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

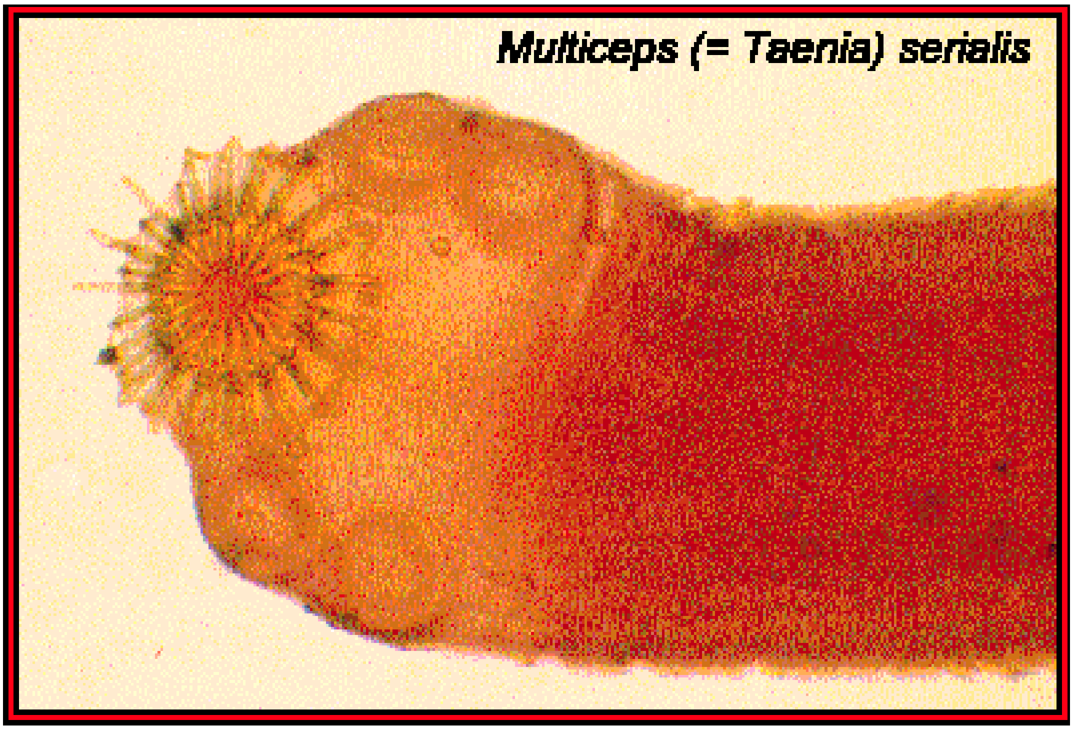
Taenia serialis

(= *Multiceps serialis*)

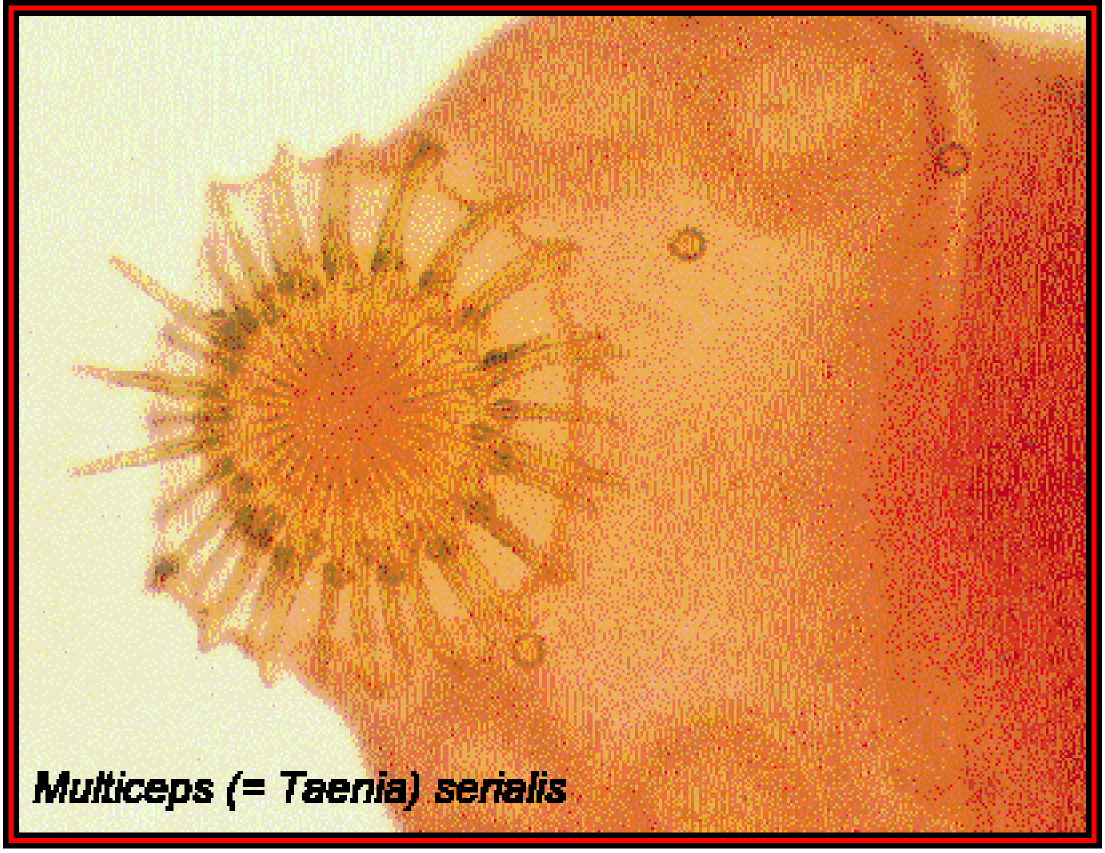
There are several species of cyclophyllidean cestodes that produce a cenurus (pl. = cenuri) as the metacestode stage. A cenurus is similar to a cysticercus, but contains many scoleces. Cestodes with this type of metacestode are placed in the genus *Multiceps* by some authors and in the genus *Taenia* by other authors.

The life cycle of this parasite involves warm blood vertebrates as both the intermediate and definitive hosts. The intermediate host is a rabbit or hare, and the definitive host is a dog or other canine.

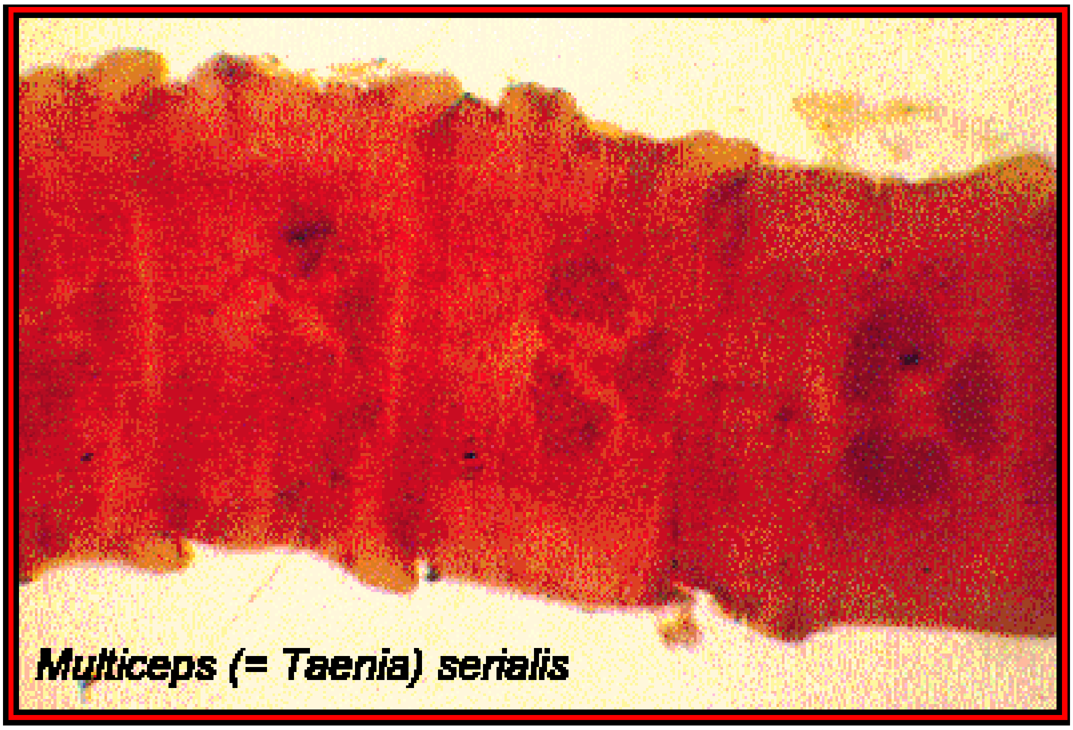
Infections with cenuri can cause pathology in the intermediate host. Human infections (acquired by accidental ingestion of eggs) have been reported. The cenuri of *T. multiceps* (sometimes called *Cenurus cerebralis*) can infect the brains of sheep, causing a disease referred to as "gid" or "staggers." These terms refer to the behavior of sheep infected with this parasite.



A stained whole mount of the scolex of *Taenia serialis* recovered from a dog. The four suckers and armed rostellum are visible in this preparation.



A higher magnification of the above image showing the rosette of hooks.



A stained whole mount of mature proglottids of *Taenia serialis*. Although many of the organs can not be seen, the single posterior vitelline gland and bilobed ovary, characteristic of cyclophyllidean tapeworms, can be seen.

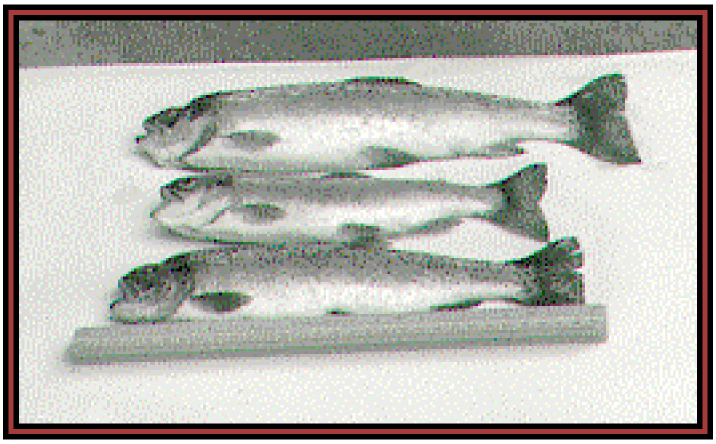
Myxobolus (= *Myxosoma*) *cerebralis*

(causing "whirling disease")

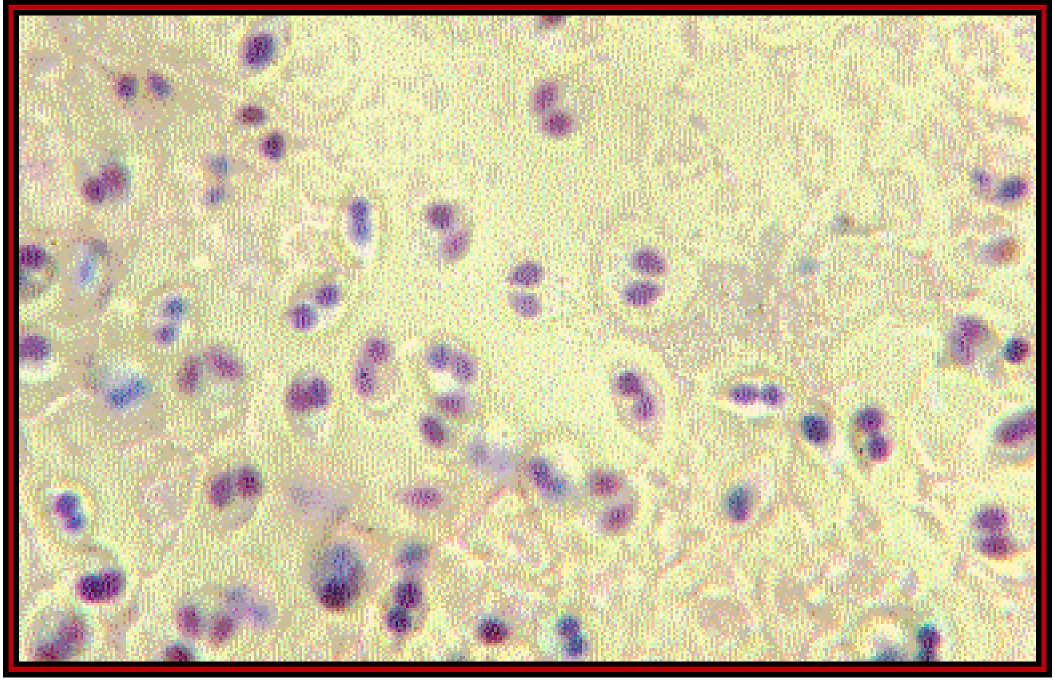
Species of *Myxobolus* infect many species of fish. Probably the best known representative of this genus is *M. cerebralis*, the cause of "whirling disease" in salmonid fish. The disease gets its name from the fact that infected fish, when they eat or become confused, often swim in circles. The parasite is widely distributed, being found in many parts of Europe, the USA, South Africa, and New Zealand. It is a particularly serious problem in fish hatcheries.

When a fish is infected, the parasite enters the cartilage of the head and spinal cord. As the parasite reproduces the cartilage is damaged. Associated with this is neurological damage, resulting in the "whirling" behavior. Infected fish may also display physical deformities, notably curvature of the spine and an indentation in the top of the head. In young fish, the mortality rate is very high, probably due to neurological damage and increased predation.

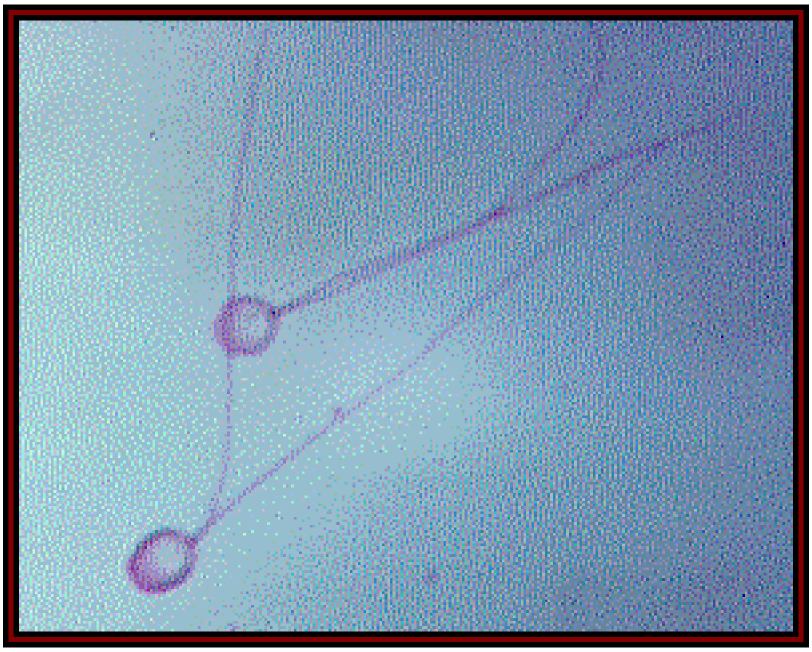
The infection is transmitted via "spores" that are produced in infected fish. There are several mechanisms that appear to be responsible for the liberation of spores into the environment. It is unclear if the spores can exit a fish while it is still alive. However, as dead fish decay, spores can be liberated. If a fish is eaten by a predator (e.g., a bird), the spores will be passed in the predator's feces. (This can also disseminate the infection to new geographic areas.) There is no known treatment for this parasite.



Three fish infected with "whirling disease." Note that the top of the head of each is indented, a characteristic feature of this infection.



A histological section of cartilage from a fish infected with "whirling disease." The developing "spores" (blue dots) are clearly visible.



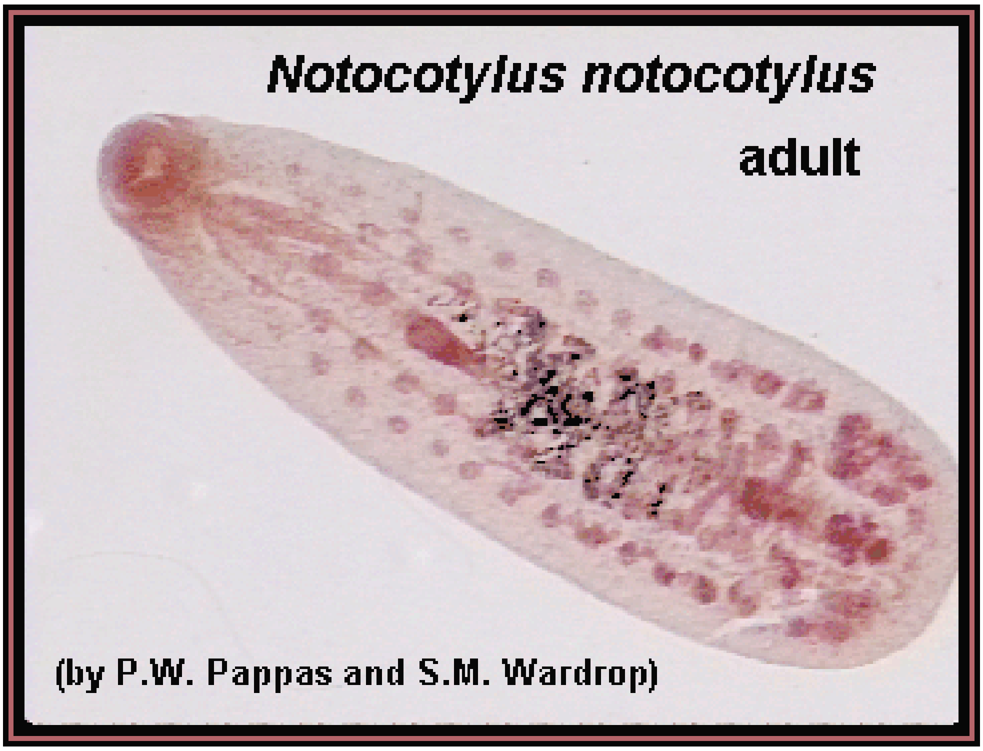
Two "spores" of *Myxobolus* with the polar filaments extended. This is the stages that is responsible for transmission of the parasite among hosts.

Graphic Images of Parasites

Notocotylus notocotylus

(a monostome trematode)

Notocotylus notocotylus, also known as *Quinqueserialis quinqueserialis*, is a common parasite of muskrats, voles, and mice throughout much of the United States and Canada. It is an unusual trematode in that it has only an oral sucker (hence, it's a monostome), and its ventral surface is lined with rows of glands or papillae. The adult worms, which average about 6 mm in length, reside in the host's cecum, eggs are passed in the feces, and the first intermediate host is a snail. Cercariae that emerge from the snail encyst on vegetation, and the definitive host is infected when it eats vegetation contaminated with metacercariae (view a diagram of the life cycle).

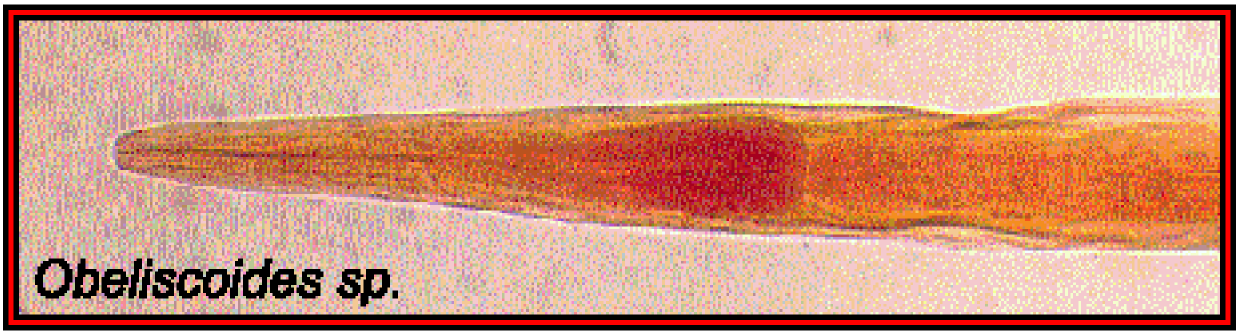


Notocotylus notocotylus, adult, stained whole mount; approximate size = 5 mm in length. Click here to view an image of this parasite in which the internal organs are labeled.

Obeliscoides sp.

The best known representative of this genus is *Obeliscoides cuniculi*, often called the rabbit stomach worm. This parasite is found in many species of rabbits and hares throughout much of Mexico, Canada, and the United States. You can view a diagram of the life-cycle here.

The posterior end of a male *Obeliscoides* sp. recovered from a rabbit.

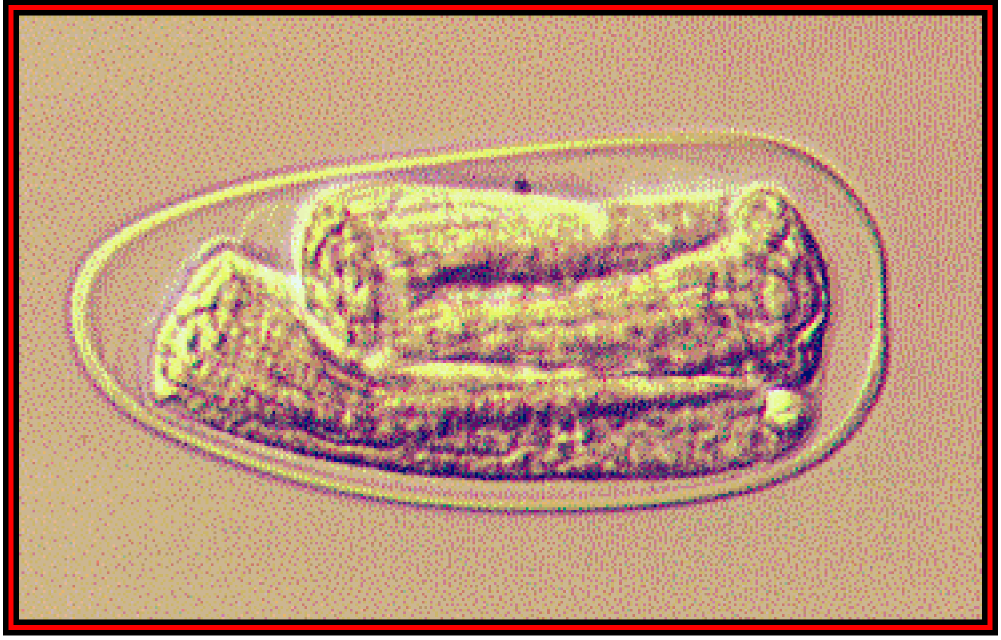


The anterior end of the specimen shown in the above image.

The following images were scanned from slides provided by Dr. Lena Measures, Maurice Lamontagne Institute, Fisheries and Oceans Canada, Mont-Joli, QC, Canada, and used with permission. Some of the scanned images were modified slightly for this web site.

Adult female and male *Obeliscoides cuniculi* from a snowshoe hare.


An unembryonated egg of *Obeliscoides cuniculi* passed in the feces of a snowshoe hare.



An embryonated (larvated) egg of *Obeliscoides cuniculi*.

Graphic Images of Parasites

Octomacrum sp.

A whole mount of the opisthaptor of *Octomacrum* sp. (probably *O. lanceolatum)*. Note that the opisthaptor is composed of eight small "suckerlets" or "clamps."

Graphic Images of Parasites

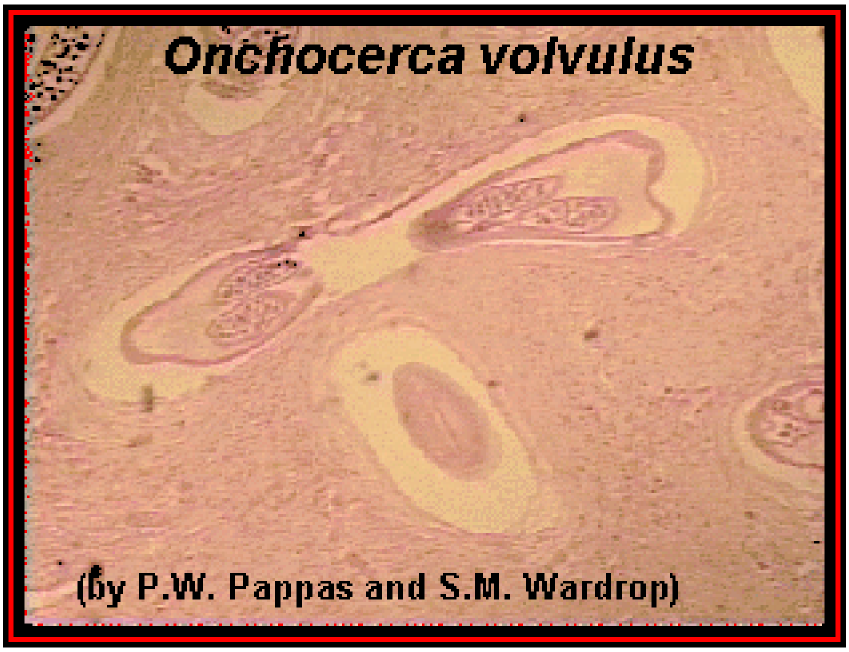
Onchocerca volvulus

(Onchocerciasis or river blindness)

Onchocerciasis is distributed throughout much of the world, including parts of Africa, Arabia, Central America, northern South America, and Mexico (view geographic distribution). In Africa alone it is estimated that more than 30 million people are infected with this parasite.

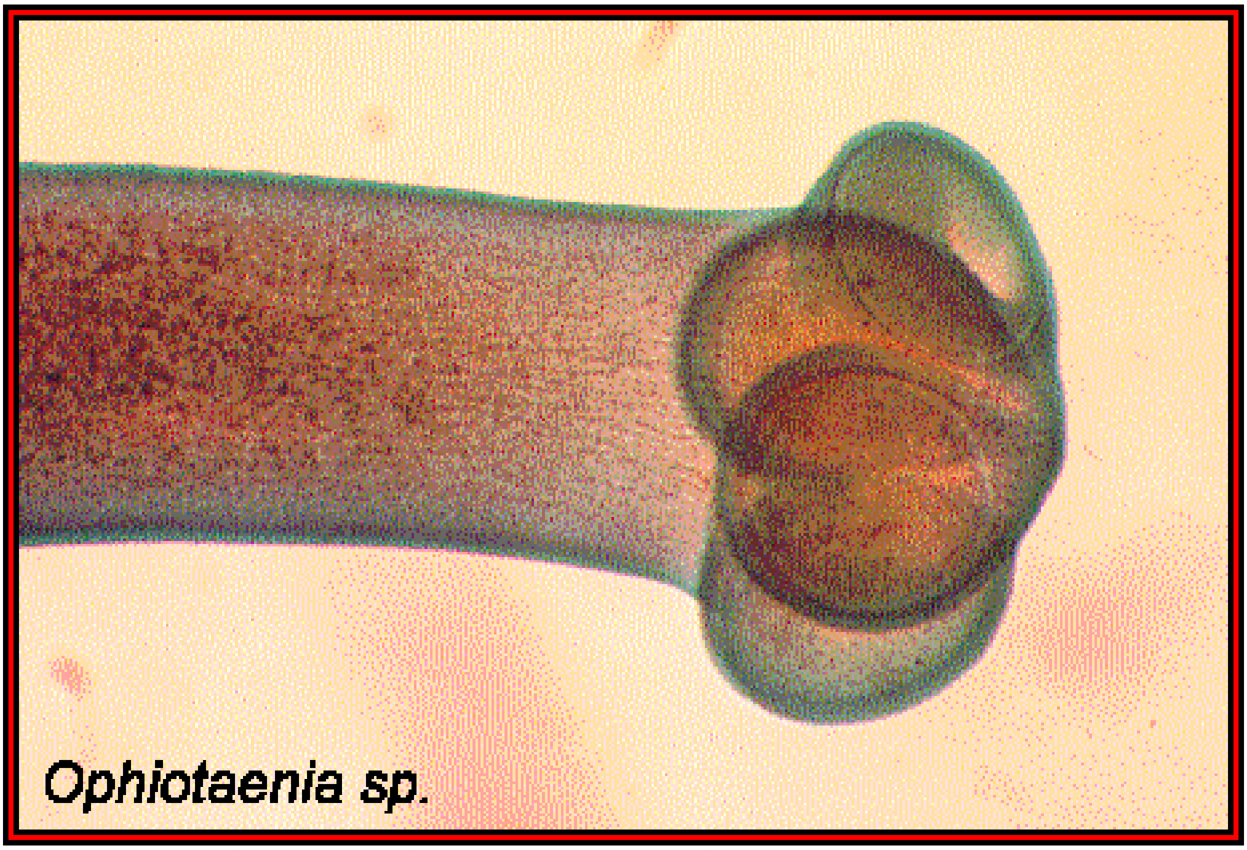
The life cycle of this parasite is similar to that of other filarial parasites. The adult worms live in the skin of humans. The adults (which may be up to 50 cm long) are surrounded by fibrotic tissue (a result of the host's response to the parasite), and this fibrotic capsule often appears as a nodule under the skin. The female worms produce microfilariae (advanced embryos), and the microfilariae remain in the skin. The vector for this parasite is a black fly (*Simulium* sp.), and the vector is infected when it feeds on an infected human. The microfilariae develop into infective larvae in the vector, and the disease is transmitted to another human via the infective larvae. Once the infective larvae are in the human they do not migrate; rather they develop to adults at the site of the vector's bite (view diagram of the life cycle).

Unlike most other filarial infections in which it is the adult worms that cause the problem (e.g., bancroftian filariasis), with *O. volvulus* it is the microfilariae that cause most of the problems. The microfilariae enter the eye and die, and this eventually results in blindness. In some areas of endemic disease, 30-40% of the adult population is blind as a result of this disease. (The vector breeds in rivers, so this disease occurs most often in areas adjacent to rivers; hence the name "river blindness.") The death of microfilariae in the skin can also result in a severe dermatitis accompanied by depigmentation. This depigmentation, in combination with the nodules that contain the adult worms, can result in severe disfigurement.



Section of a skin nodule containing adults of *Onchocerca volvulus*. In this section you can see the cross-sections of the adult worms, and the dense connective tissue surrounding the worms.

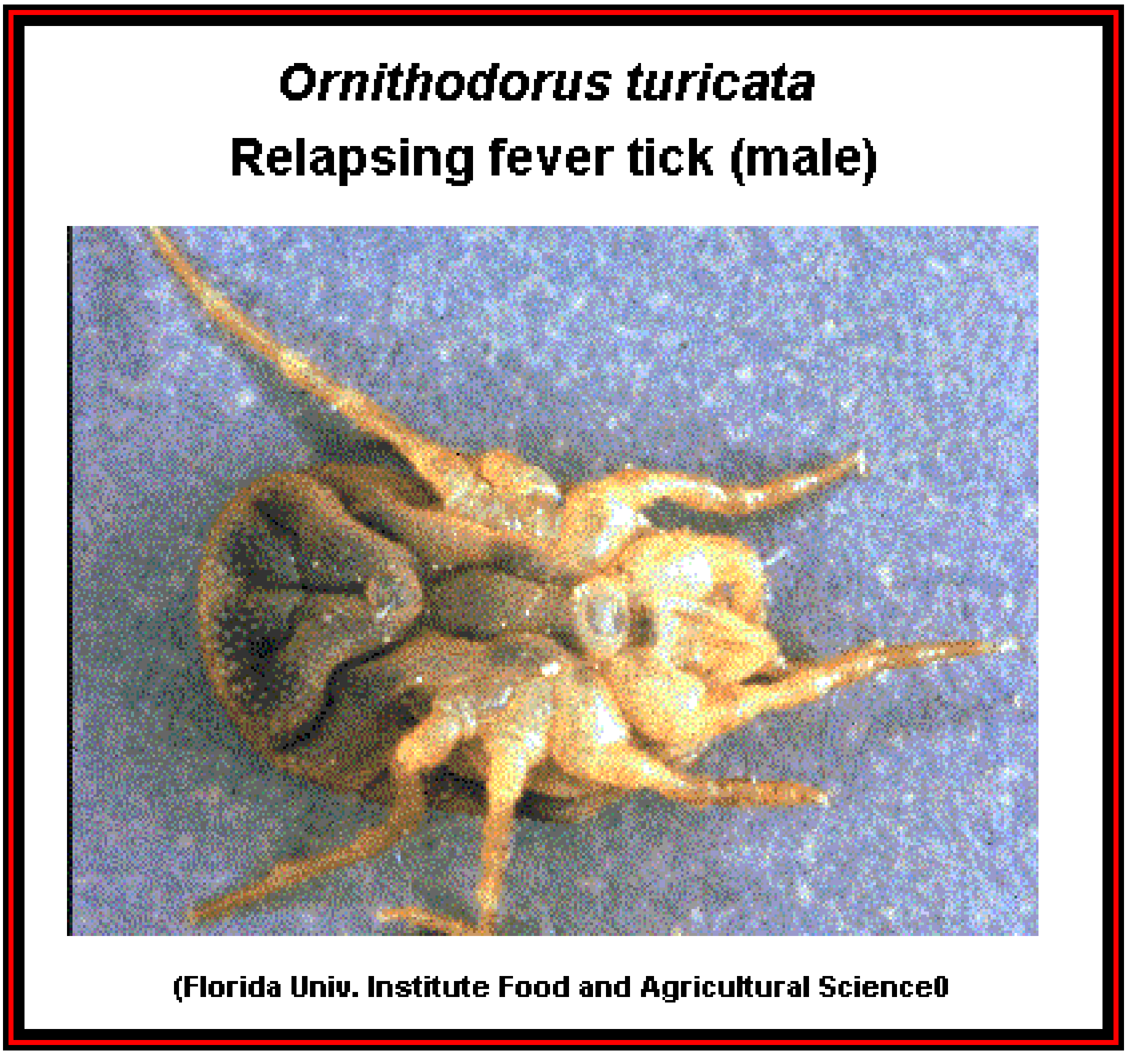
Ophiotaenia sp.



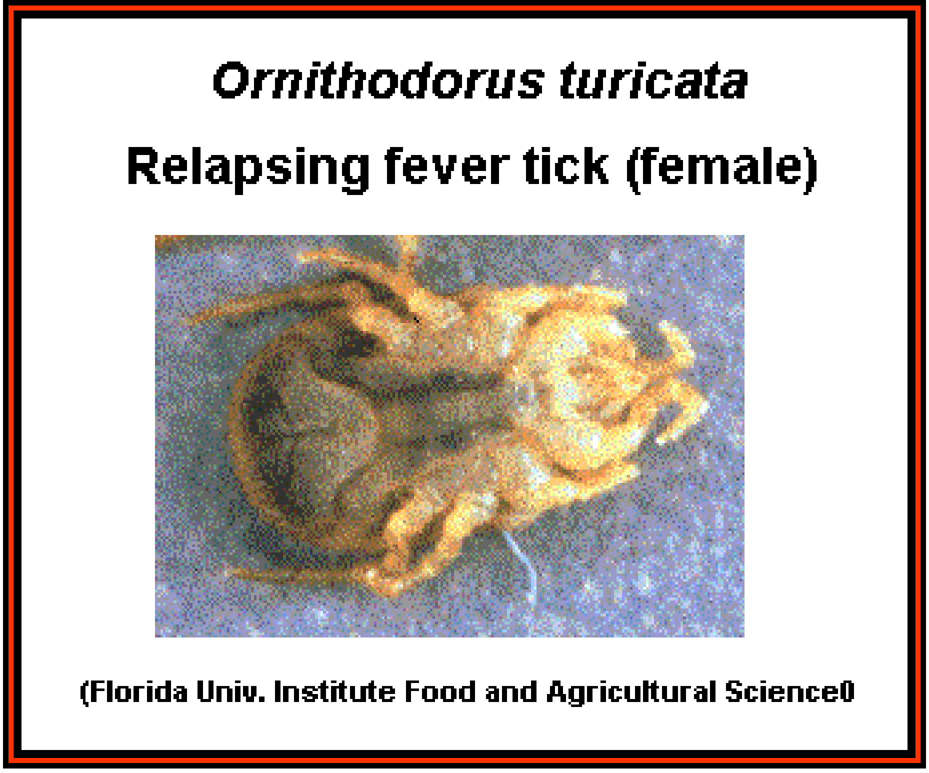
A stained whole mount of the scolex of *Ophiotaenia* sp. The four suckers are clearly visible in this preparation.

Ornithodorus turicata

Ornithodorus turicata and similar species are vectors for relapsing fever; hence it is often called the relapsing fever tick. Most relapsing fevers do not infect humans, although localized epidemics have been reported. This species has also been implicated as a possible vector for Rocky Mountain spotted fever.



A male *Ornithodorus turicata*

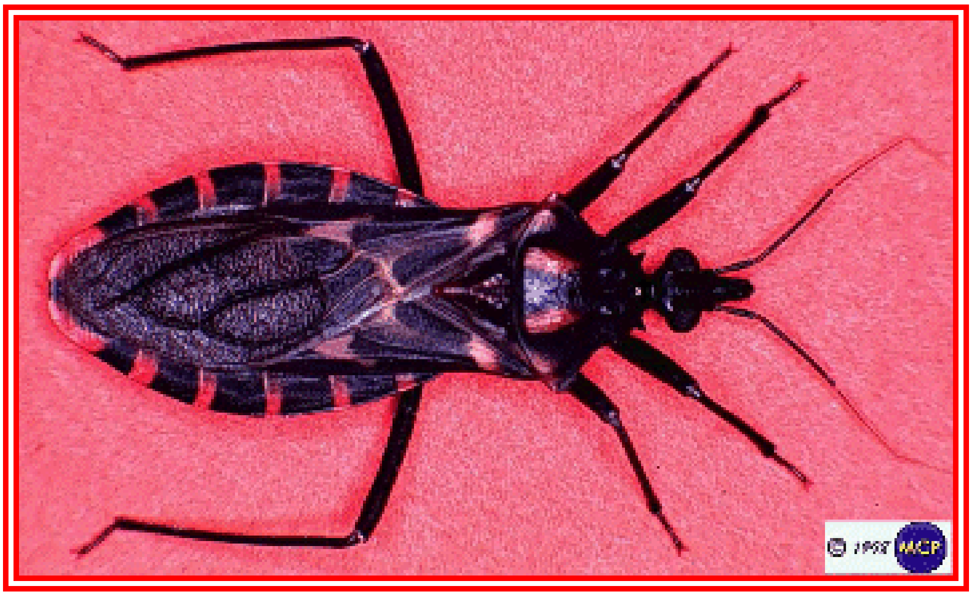


A female *Ornithodorus turicata*

Panstrongylus megistus

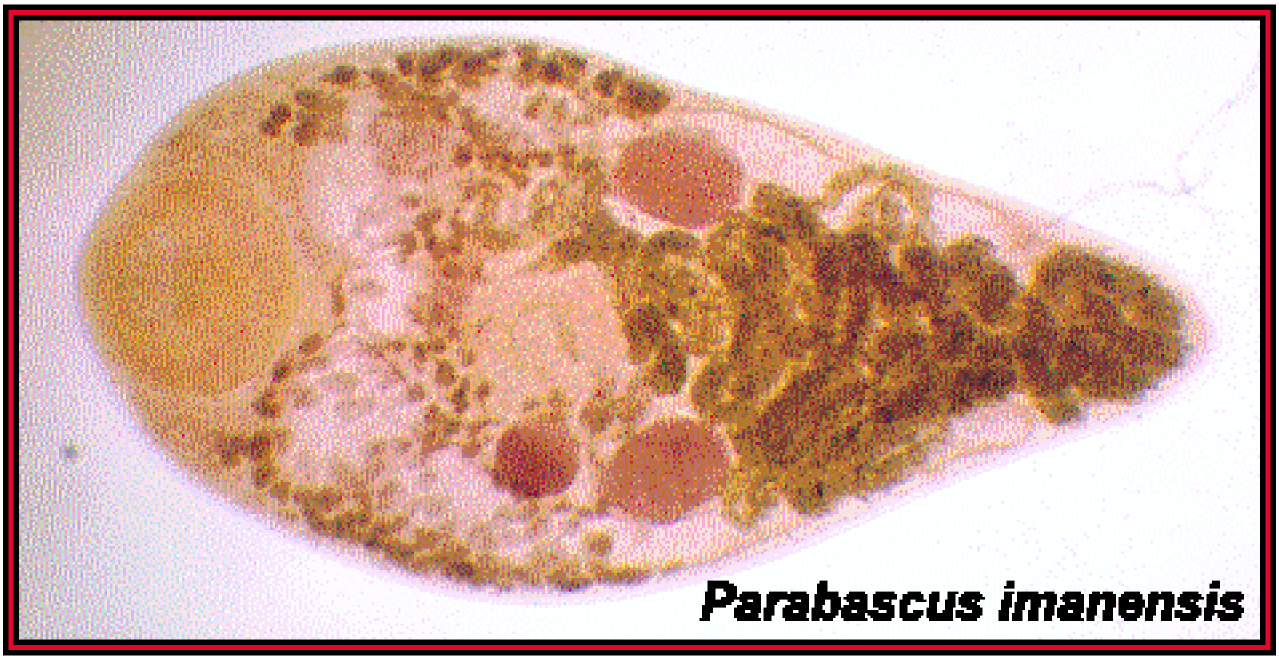
Members of the genus *Panstrongylus*, and the related genera *Rhodnius* and *Triatoma*, serve as vectors for Chagas' disease (American trypanosomiasis).

Panstrongylus megistus. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)



Panstrongylus megistus. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Parabascus sp.



A stained whole mount of an adult *Parabascus imanensis*. The oral sucker is on the left side of the image.

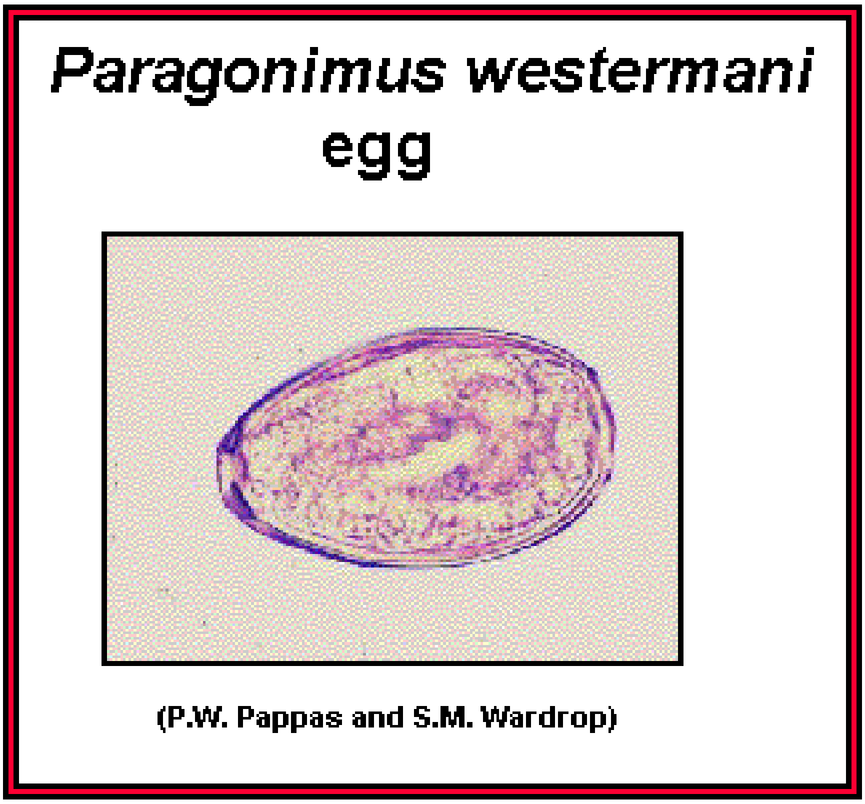
Graphic Images of Parasites

Paragonimus westermani
(human lung fluke)

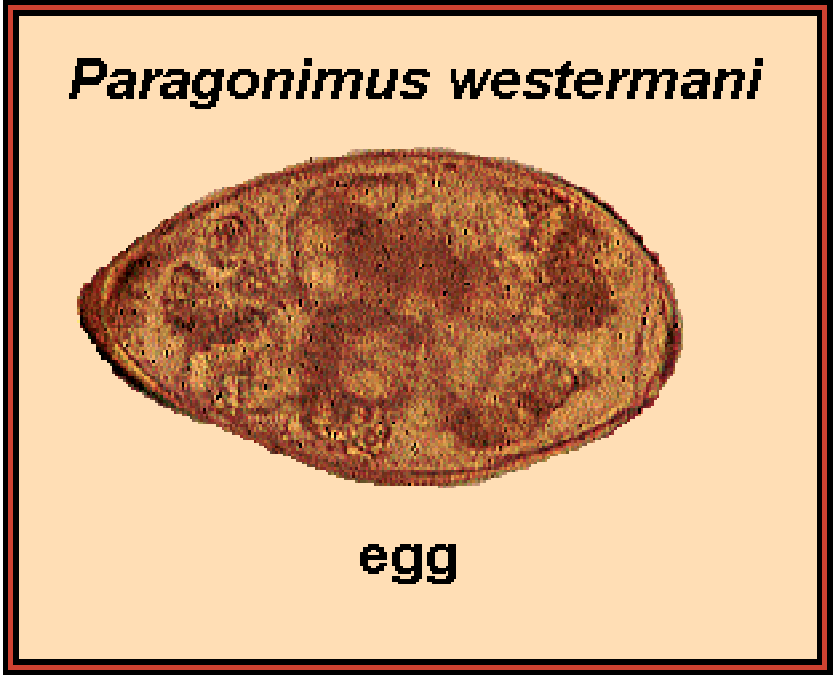
Many species (about 50) of *Paragonimus* have been described from mammals, including humans, but the validity of many of these species is questionable. Regardless, it is clear that *Paragonimus* is an important zoonosis in that infections are often transmitted from animals to humans. The species that infects humans most often is *Paragonimus westermani*.

Adult *P. westermani* are found most often in the lungs of the human host. The adult worms are robust, measuring about 10 mm in length, 5 mm in width, and 5 mm in depth. The worms produce eggs that are passed into the air passages of the lungs, and the eggs are coughed up and spit out or swallowed and passed in the host's feces. The eggs develop and hatch, and the first intermediate host is a snail. The cercariae that are produced infect the second intermediate host, a crab or crayfish, and the definitive host is infected when it eats a crab or crayfish infected with metacercariae. The metacercariae excyst in the host's small intestine and the immature worms penetrate the host's small intestine. From here they migrate through the abdominal cavity, penetrate the diaphragm, and finally burrow into the lungs (view diagram of the life cycle). Pulmonary paragonimiasis can be disabling, but it is rarely fatal. However, the worms are often found in ectopic locations such as the brain, heart, or spinal cord, and when present in these locations the infections can be fatal.

Crabs and crayfish are generally not eaten raw even in areas of endemic paragonimiasis (view diagram of geographic distribution). Transmission to humans probably occurs most often via pickled or marinated crabs or crayfish (in which metacercariae remain viable), or via contaminated fingers or cooking utensils.

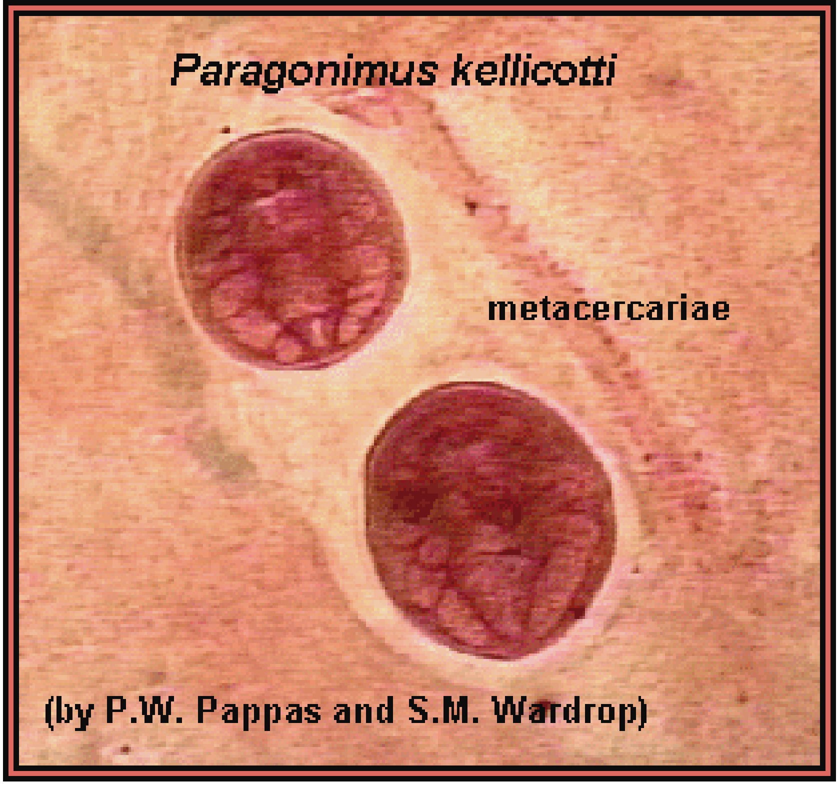


Paragonimus westermani egg; approximate size = 90 µm in length.

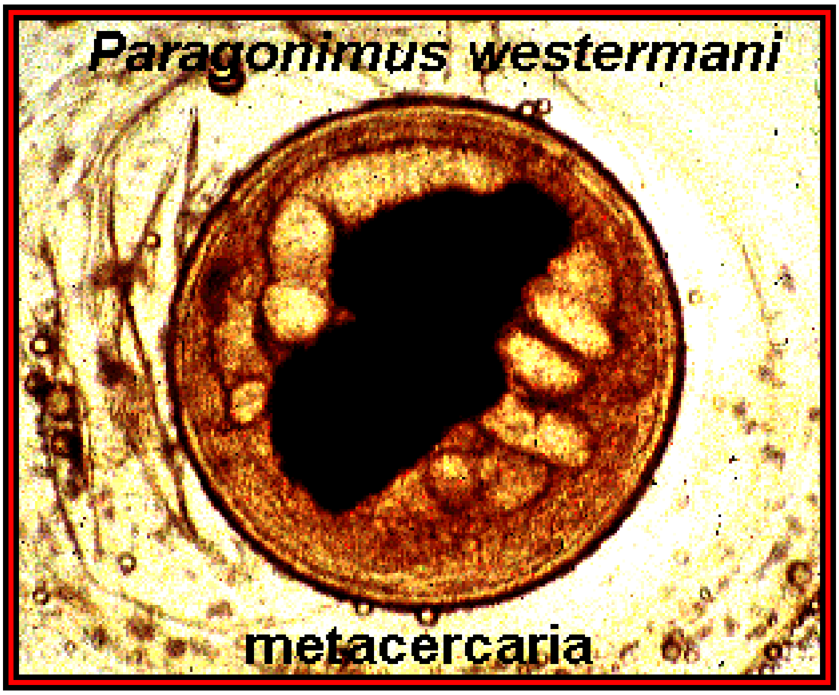


Another example of a *Paragonimus westermani* egg.

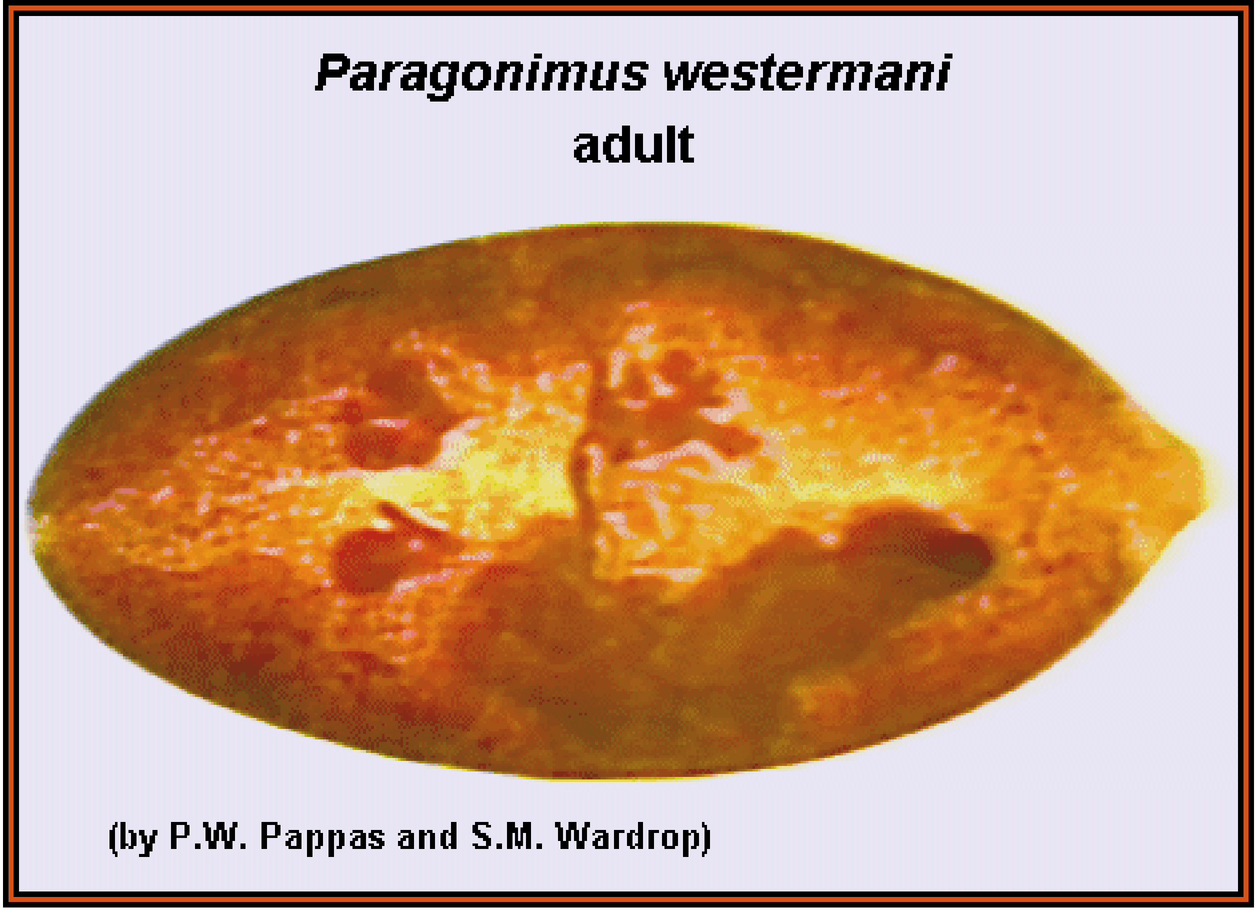
And a third example of a *Paragonimus* egg. (Original image from a Japanese language site tentatively titled Internet Atlas of Human Parasitology.)



Metacercariae of *Paragonimus kellicotti* in the heart of a crayfish. This species was named after the first chairman of the Department of Zoology at The Ohio State University.)



Metacercariae of *Paragonimus westermani*.



Paragonimus westermani, adult, stained whole mount; approximate size = 9 mm in length. Click here to view an image in which some of the internal organs are labeled, or click here to view a labeled line drawing.

Graphic Images of Parasites

Philometra sp.

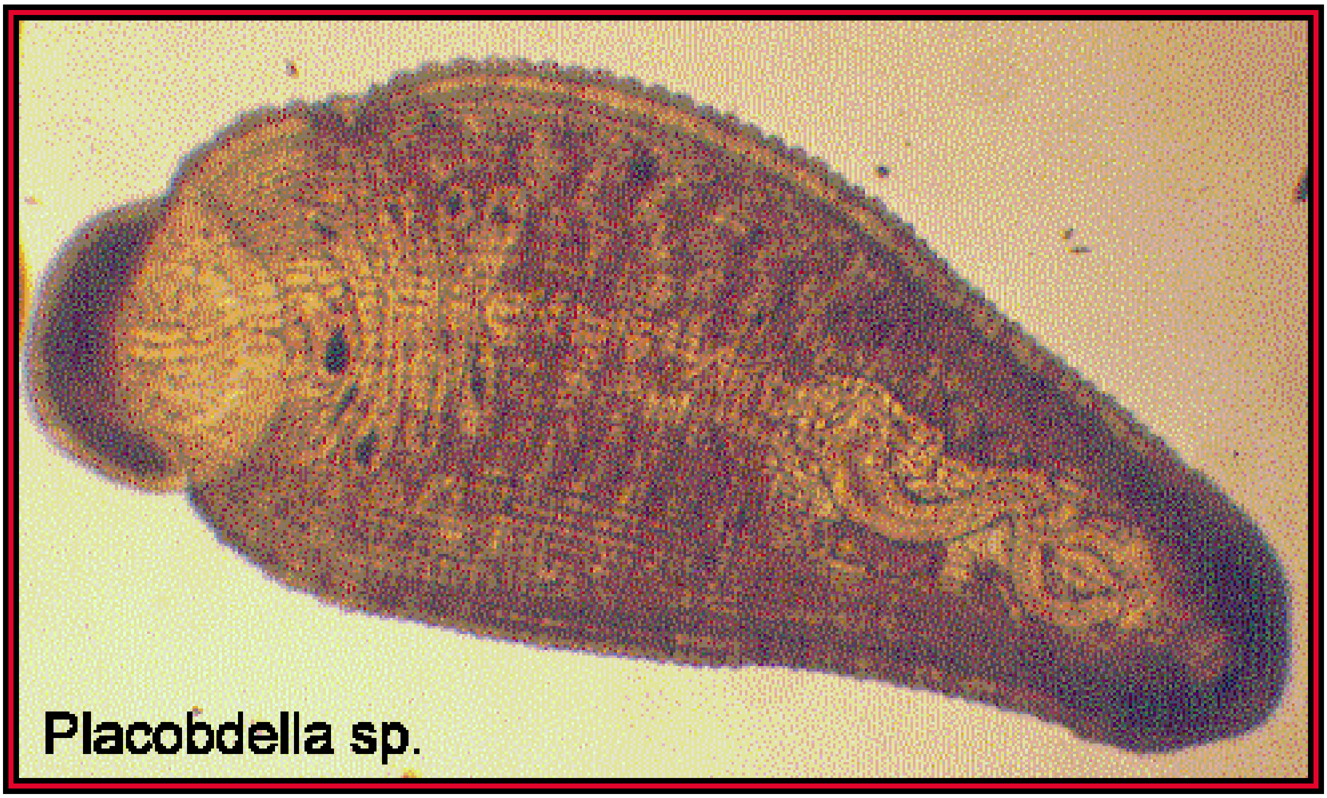
Members of this genus are parasites of the body cavities or tissues of fish. The females produce juveniles which, upon exiting the host, must be eaten by a cyclopoid copepod. The juveniles become infective while in the copepod, and the definitive host is infected when it eats an infected copepod.

Lesions in the skin of a yellow perch caused by *Philometra cylindracea*.

Placobdella sp.

Members of this genus are common parasites of amphibians and reptiles. Several species within this genus also serve as vectors for other parasitic diseases. For example, *P. marginata* can serve as the vector for *Trypanosoma rototarium*, a blood parasite (hemoflagellate) of tadpoles and frogs, and *P. catenigera* can serve as the vector for *Hemogregarina stepanowi*, a blood parasite (apicomplexan) of turtles.

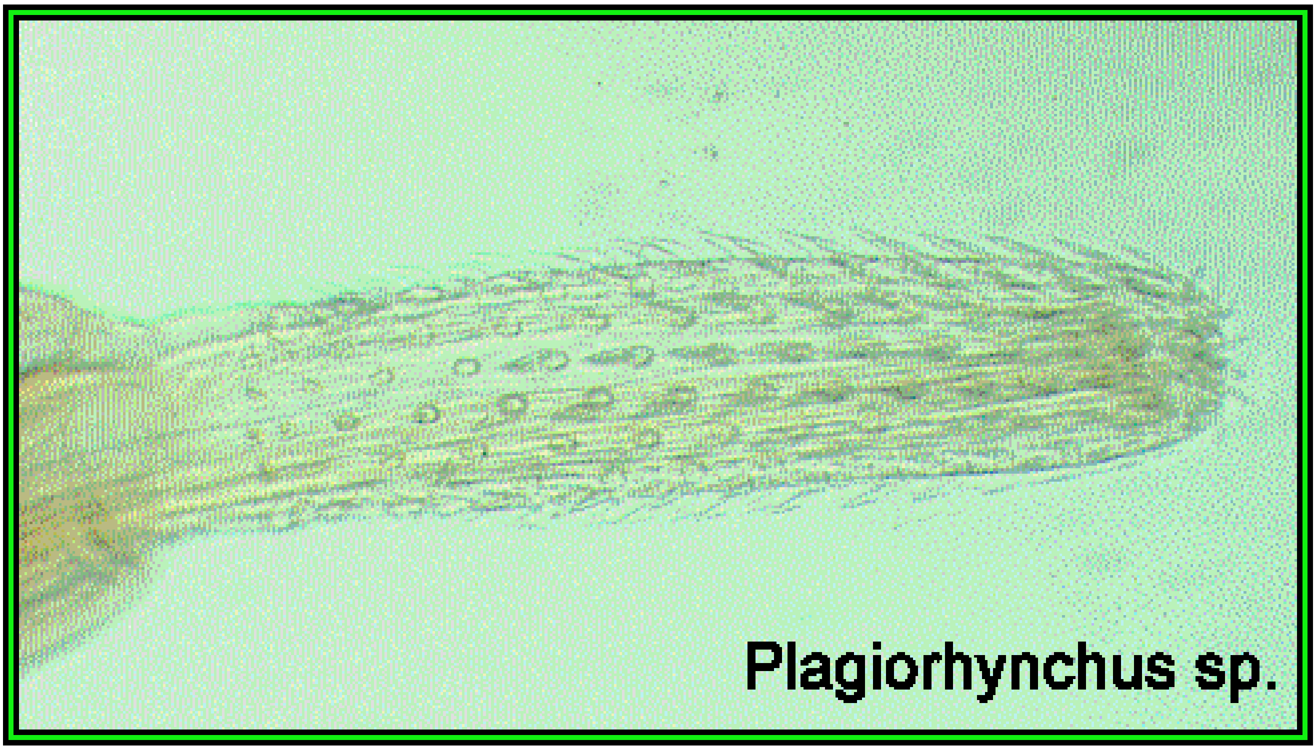
Two specimens of *Placobdella* sp. removed from a turtle.



A whole mount of an immature specimen of *Placobdella* sp.

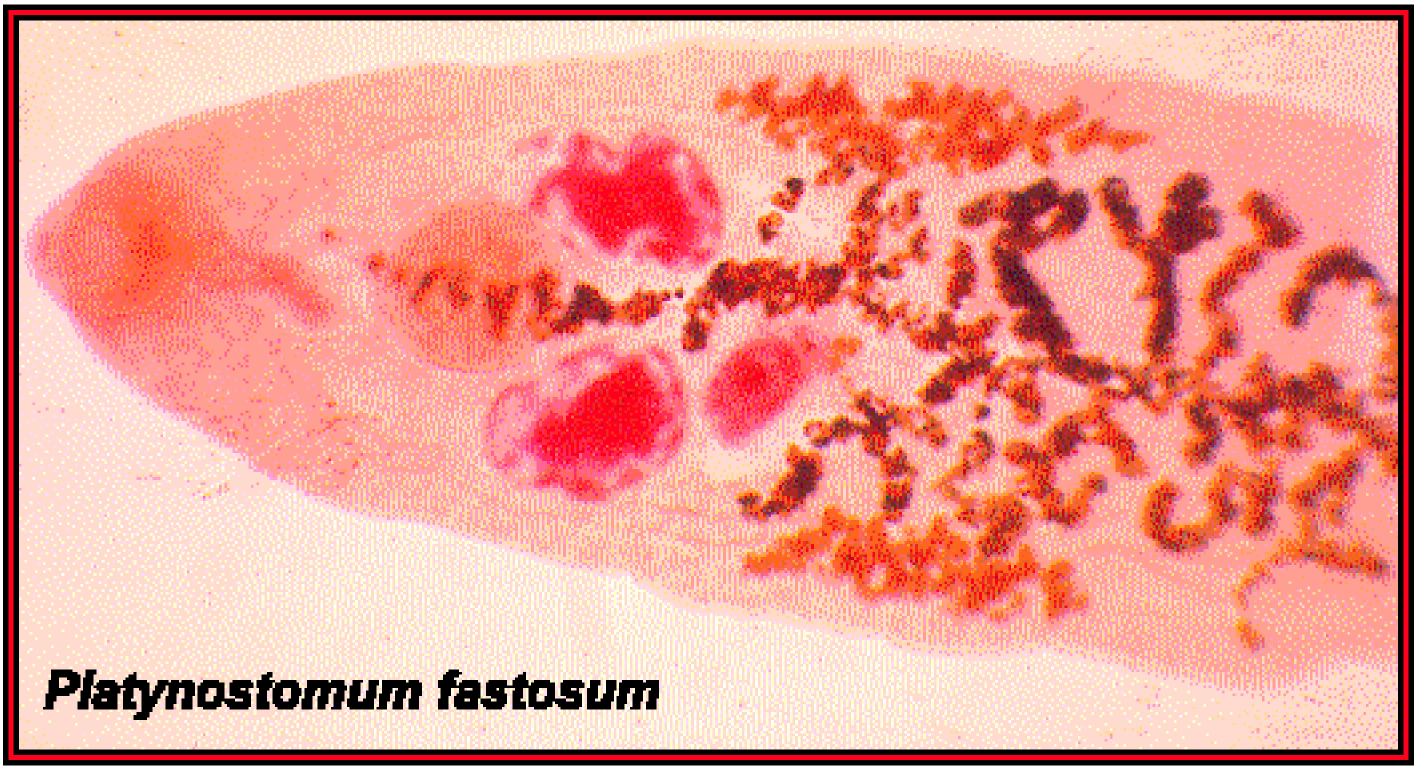
Plagiorhynchus sp.

Members of this genus utilize birds as the definitive host.



The anterior end of an adult *Plagiorhynchus* sp.

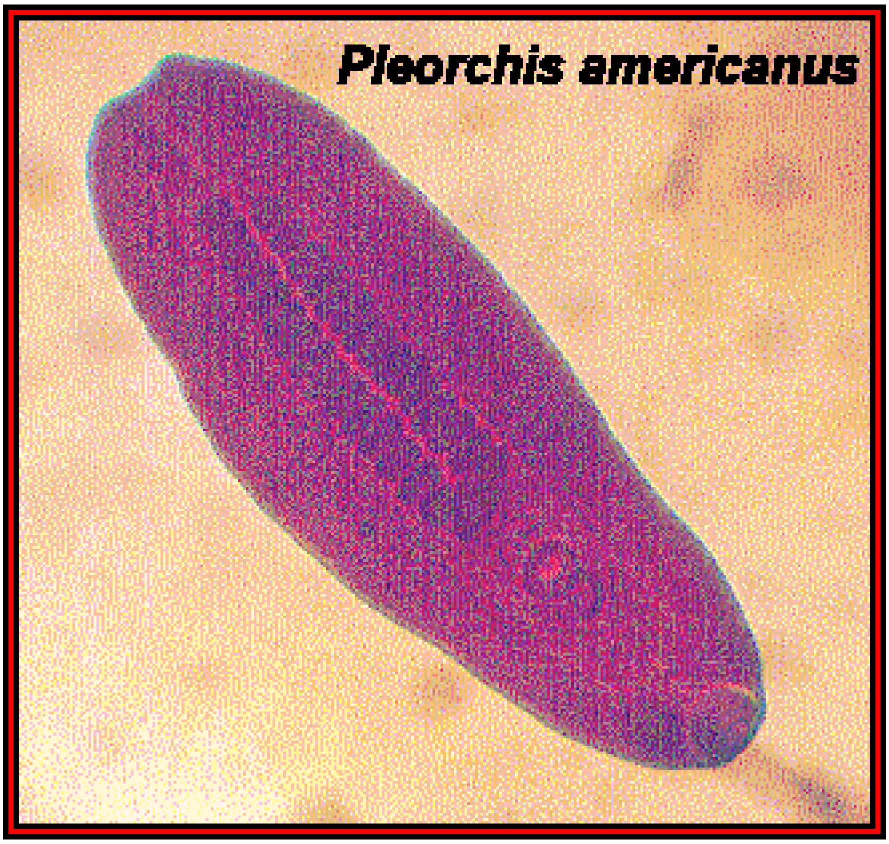
Platynostomum sp.



A stained whole mount of *Platynostomum fastosum* recovered from the liver of a cat.

Graphic Images of Parasites

Pleorchis sp.



A stained whole mount of an adult *Pleorchis americanus*. Although many of the internal organs can not be seen, the follicular testes that lie between the intestinal ceca can be seen. Such a distribution of testes is characteristic of the family Pleorchiidae.

Polymorphus minutus

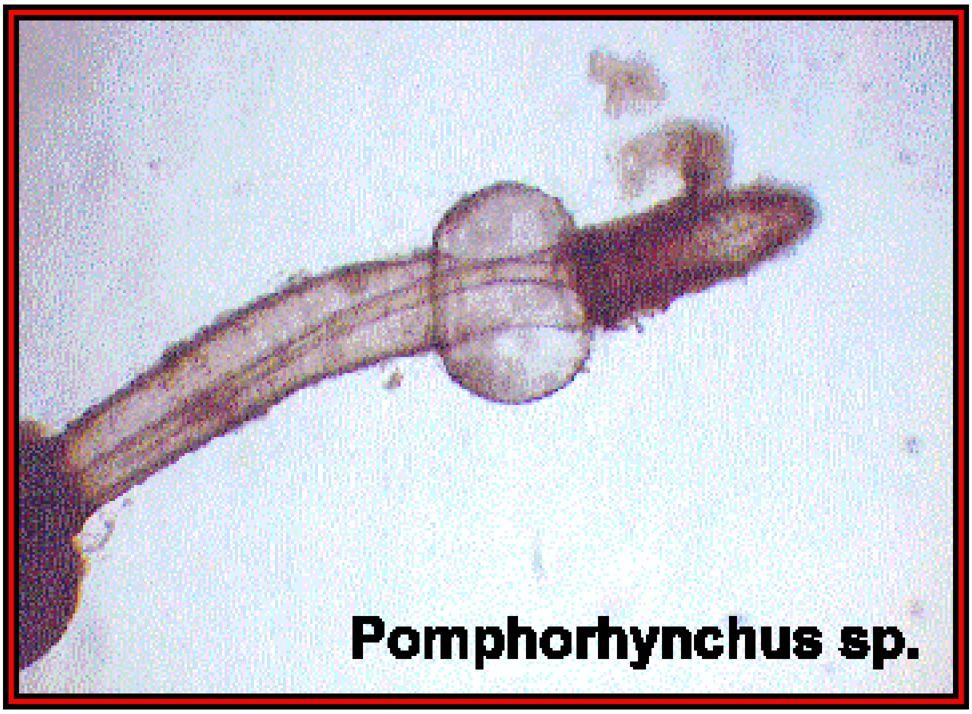
This and related species of acanthocephala are parasites of the small intestines of various species of birds. The life cycle involves an intermediate host such as a shrimp (*Gammarus* spp.) (view diagram of the life cycle).

Parasites with multiple-host life cycles must be transmitted from host to host, and several parasites have adapted uniquely to increase the probability of transmission. One of the 'classic' examples of such an adaptation is found in the digenetic trematode, *Leucochloridium macrostoma*. In the case of *Polymorphus minutus*, uninfected shrimp are brown or orange in color, while shrimp infected with the parasite are a blue color. It has been shown experimentally that birds, when given the choice of orange-colored (uninfected) or blue-colored (infected) shrimp, will eat the infected shrimp. Thus, this change in the intermediate host's color increases the probability that the definitive host will be infected.

Three specimens of *Gammarus lacustris*. The top and bottom shrimp are uninfected, while the middle specimen is infected with *Polymorphus minutus*. Note the differences in color. (Original image provided by Dr. Ole Hindsbo, Zoological Institute, Department of Population Biology, University of Copenhagen.)

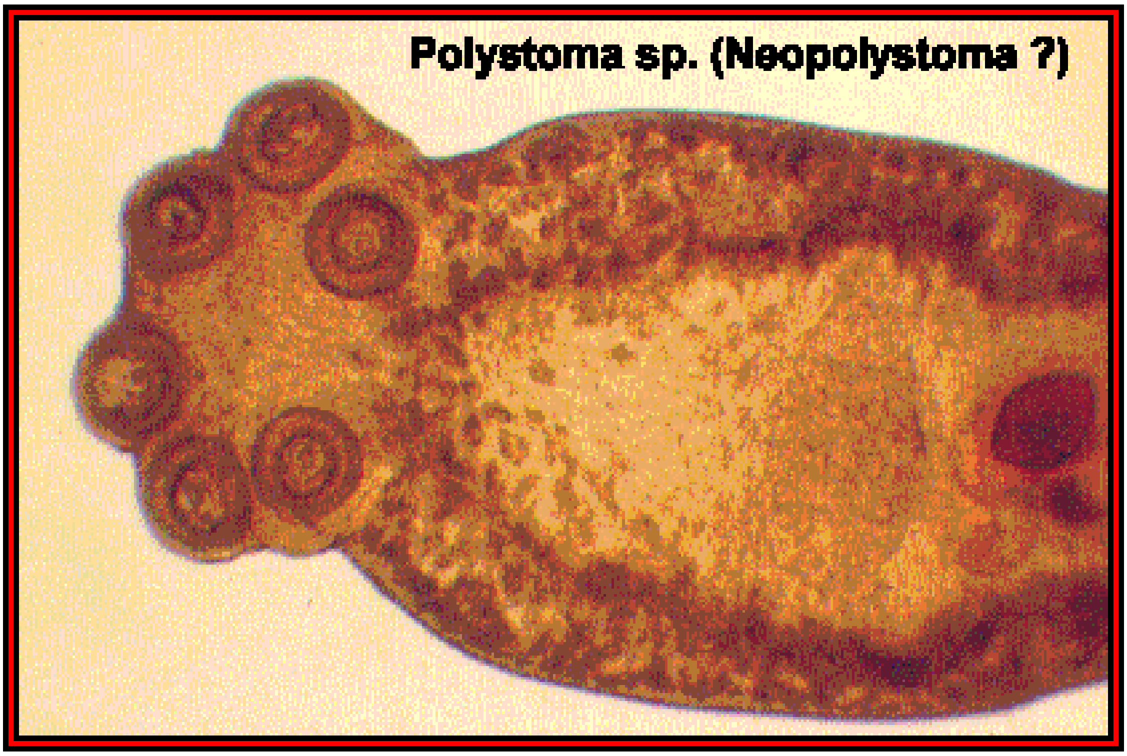
Graphic Images of Parasites

Pomphorhynchus sp.



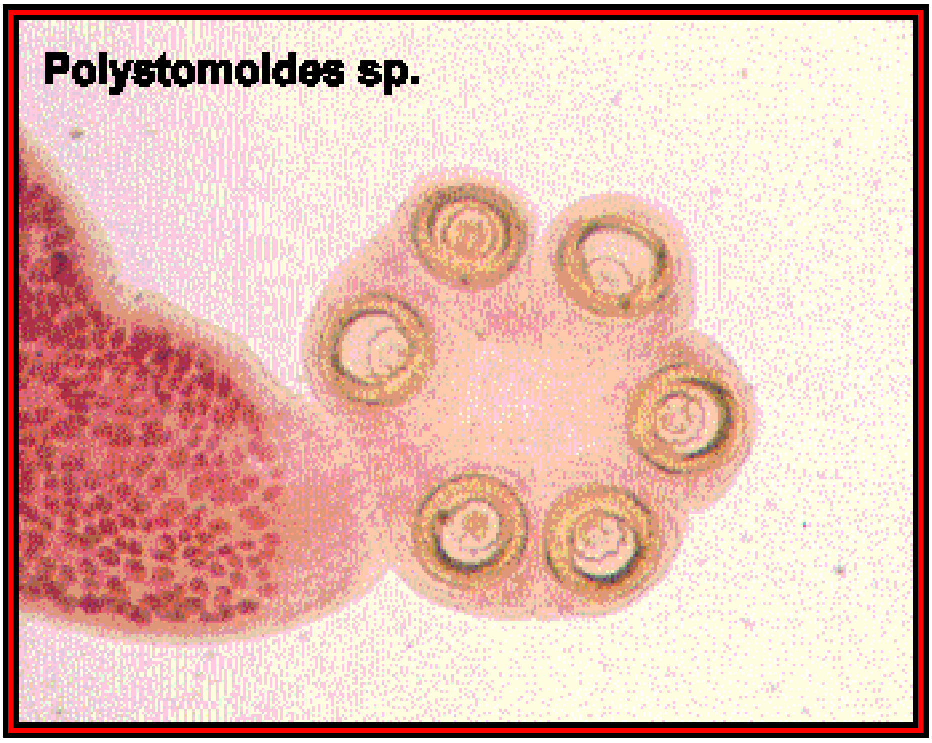
The anterior end of a specimen of *Pomphorhynchus* sp. showing the characteristic "bulbous" proboscis.

Polystoma sp.



The opisthaptor of a specimen of *Polystoma* (or *Neopolystoma*) sp. Note that the opisthaptor consists of six large suckelets.

Polystomoides sp.

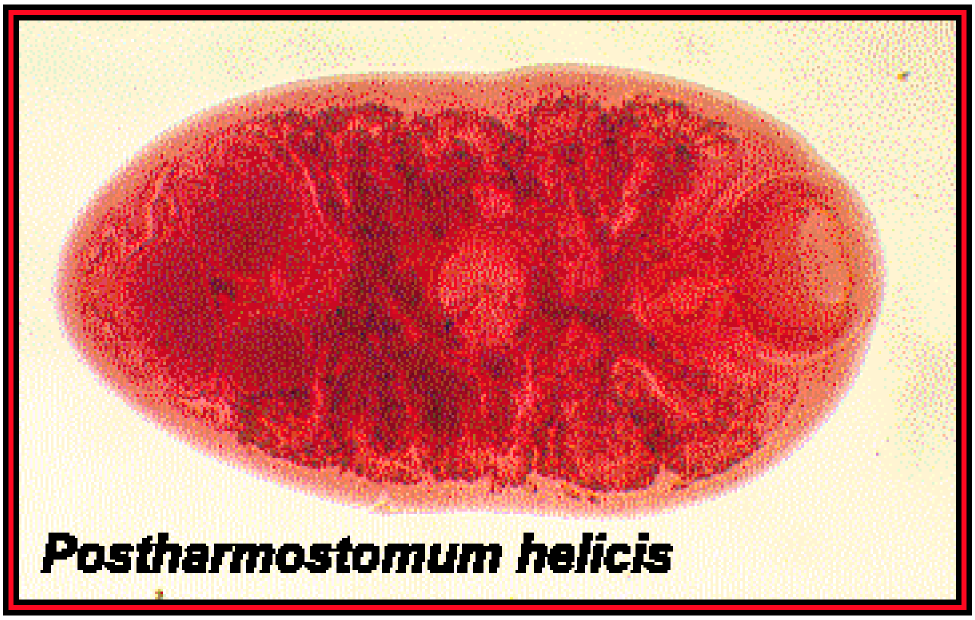


The opisthaptor of a specimen of *Polystomoides* sp. from the mouth of a turtle.

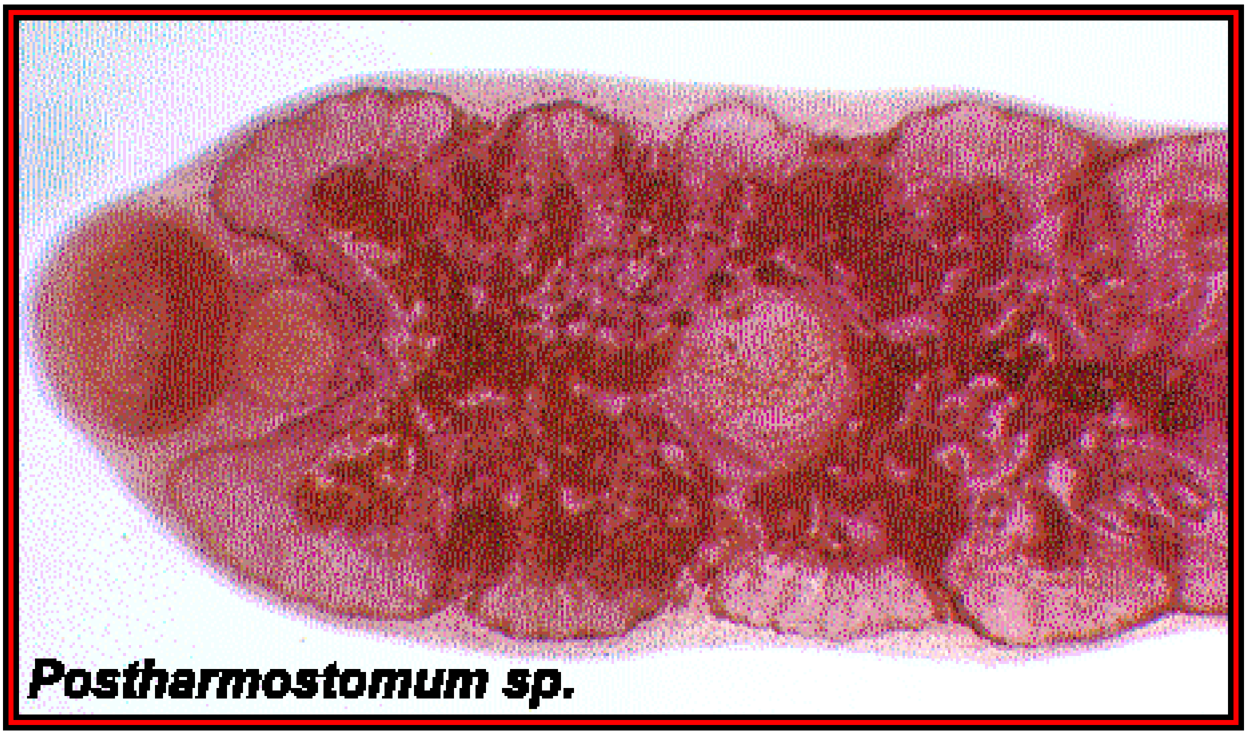
Graphic Images of Parasites

Postharmostomum helicis

This parasite is found in the cecum of mice and chipmunks. The first intermediate host is a terrestial snail, and the second intermediate host is a different species of snail. The definitive host is infected when it eats an infected second intermediate host.



A stained whole mount of an adult *Postharmostomum helicis* recovered from the cecum of *Peromyscus*.



A stained whole mount of an adult *Postharmostomum* sp. recovered from a mouse.

Graphic Images of Parasites

Prosthogonimus macrorchis

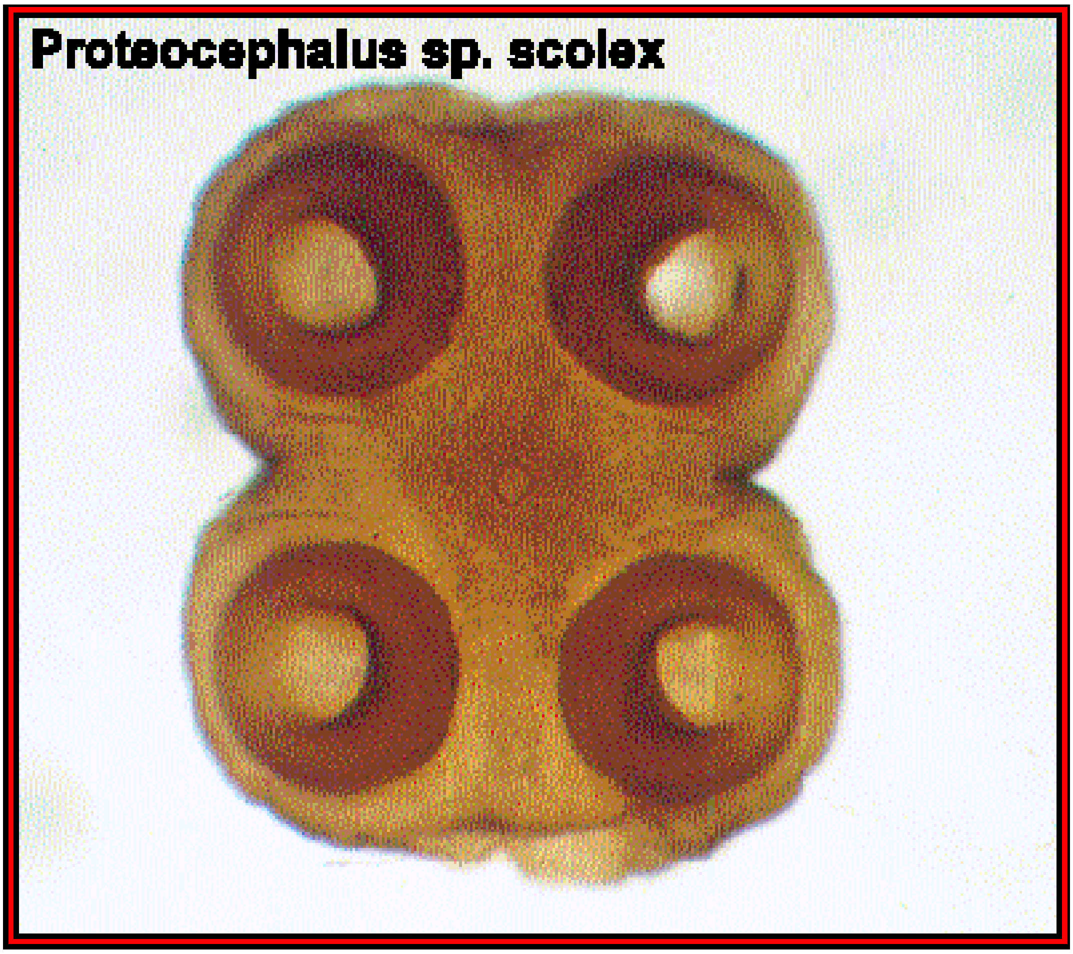
Prosthogonimus macrorchis is a parasite found in the oviducts of many species of birds, including chickens, ducks, and pheasants. The presence of this parasite can result in a marked reduction in (or complete cessation of) egg laying, so the parasite could have an economic impact in some instances. However, the parasite is probably better known because it is often used in zoology or parasitology courses to demonstrate the internal morphology of digenetic trematodes. This is because the internal organs are easily seen in stained specimens.

The adult worms average about 6 mm in length. Eggs are produced, passed in the bird's feces, and eaten by a snail. Cercariae liberated from the snail enter the anus of a dragonfly or damselfly nymph (naiad) and encyst in the muscles of the naiad. When it emerges the following year, the adult dragonfly or damselfly will contain infective metacercariae, and the definitive host is infected when it eats the infected insect. The metacercariae excyst in the bird's small intestine, and the immature worms migrate posteriorly to the bird's cloaca. From here the immature worms migrate back into the bird's oviduct (view a diagram of the life cycle). Like many parasites, including *Fasciola hepatica* and *Paragonimus westermani*, that migrate through the host's abdominal cavity, *P. macrorchis* has a well developed sense of direction.

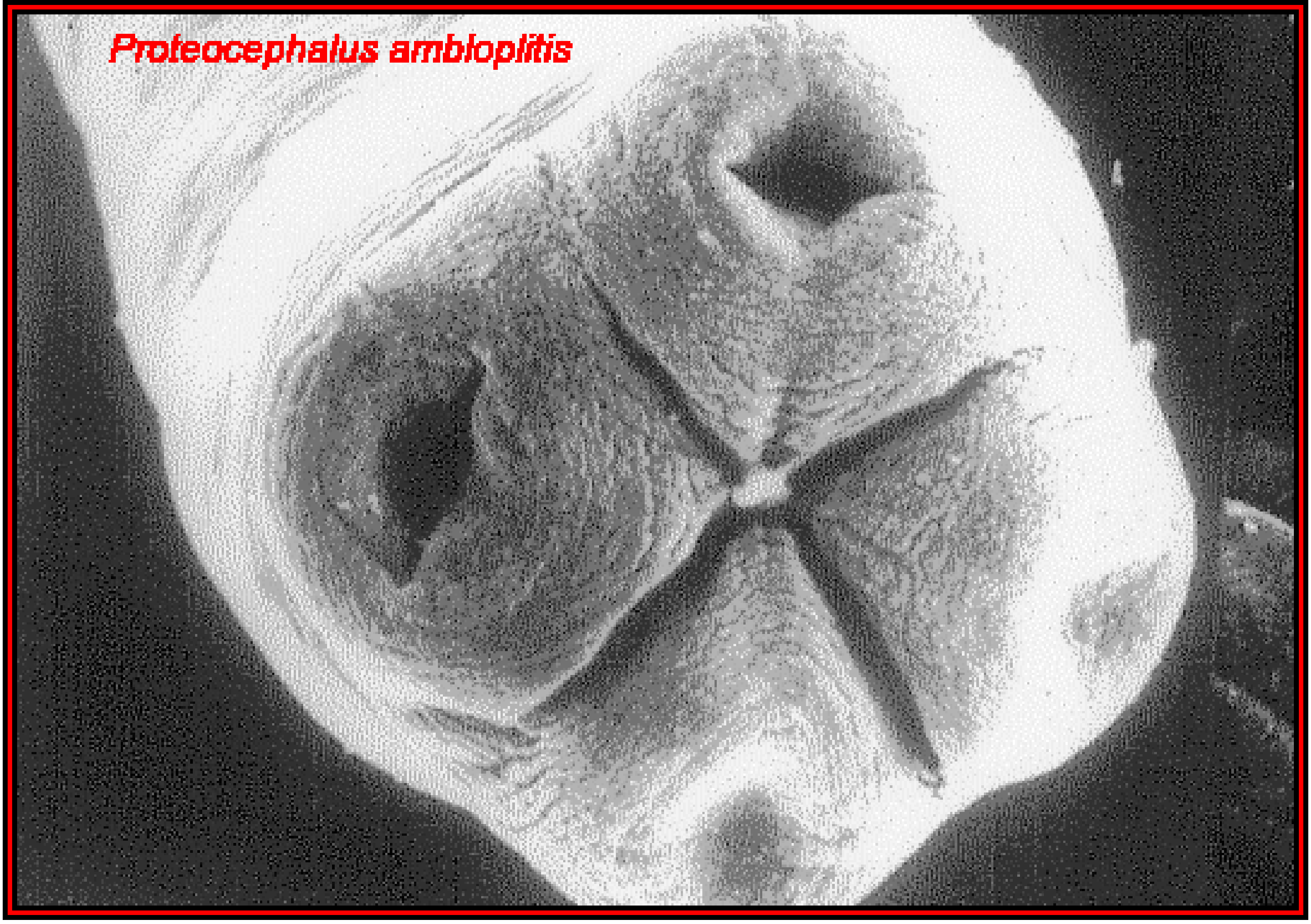
Prosthogonimus macrorchis, adult, stained whole mount; approximate size = 7 mm in length. (Click here to view a second, labeled image of this parasite.)

Proteocephalus sp.

Members of this genus occur in a variety of warm blooded vertebrates. Their life cycles are similar in that the first intermediate host is a crustacean (often a copepod), and the second intermediate host is a fish. One of the better known species is *Proteocephalus amblopitis*, a common parasite of bass, perch, and other fresh water fish. The definitive host may also serve as the second intermediate host under some circumstances. If a fish ingests a second intermediate host (e. g., a sunfish) in which the plerocercoids are not fully developed, the plerocercoids will not develop into adult worms. Rather, they will penetrate into the host's coelomic cavity and then the gonads. The plerocercoids will complete their development in the gonads, and at the same time they will likely castrate the host. Should this host be eaten by yet another fish, the plerocercoids will now develop into an adult worm.



A stained whole mount, *en face* view, of the scolex of *Proteocephalus* sp. Note the four suckers and the absence of a rostellum.

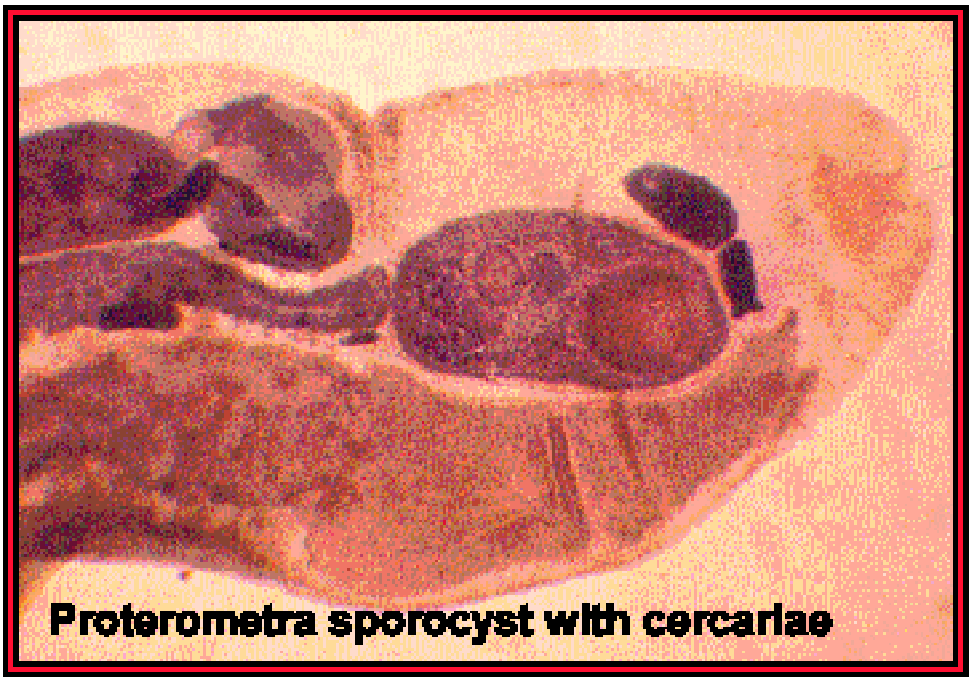


A scanning electron micrograph of the scolex of *Proteocephalus amboplitis*.

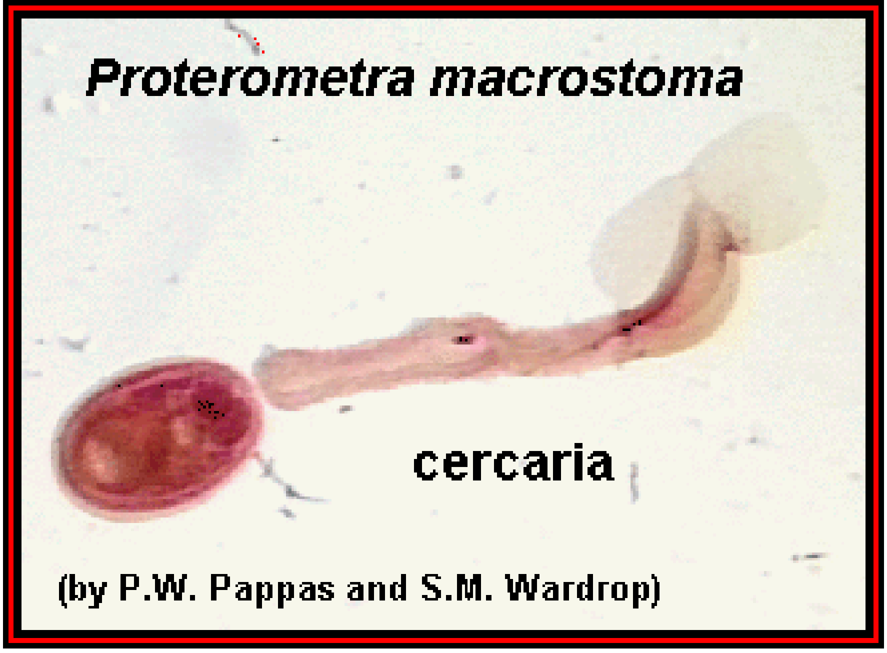
Proterometra sp.

As with most digenetic trematodes, members of this genus have a snail as the first intermediate host. However, there is no metacercarial stage, and the adults of this genus have quite different habitats. For example, *P. dickermani* actually reaches sexual maturity in the snail host (the snail is the only host in the life cycle). In *P. edneyi* and *P. macrostoma*, the definitive hosts are various species of fresh water fish. *P. edneyi* is an endoparasite (found in the fish's gut), while *P. macrostoma* is an ectoparasite (found in the pharynx or gills of the fish).

Proterometra macrostoma recovered from a sunfish.



A sporocyst of *Proterometra* sp. (probably *P. macrostoma*), with developing cercariae within.



A cercaria of *Proterometra macrostoma*. This is a furcocercous cercariae, and it is an active swimmer. The cercarial "tail" is also covered with large papillae, but these are not visible in the image.

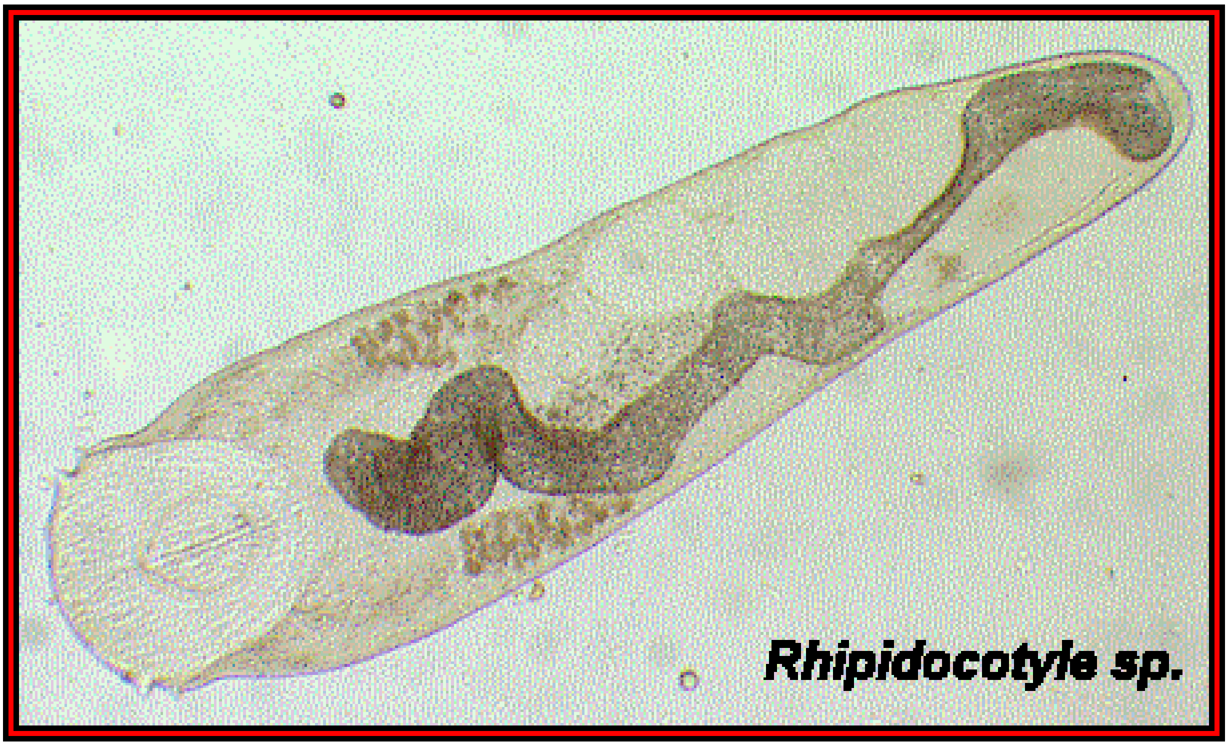
Graphic Images of Parasites

Rajonchocotyle sp.

A whole mount of *Rajonchocotyle* sp. Note that the opisthapor is composed of six "clamps." Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Ripidocotyle sp.

A stained whole mount of an adult *Rhipidocotyle* sp. recovered from a small mouth bass.

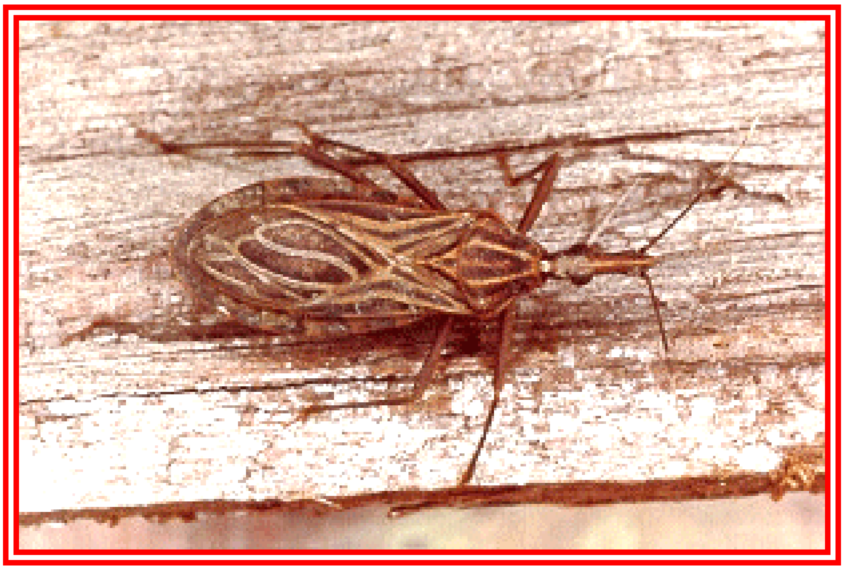


An unstained (living) specimen of *Rhipidocotyle* sp. recovered from a white bass. Notice that the oral sucker is surrounded by a muscular "hood," a characteristic of the genus.

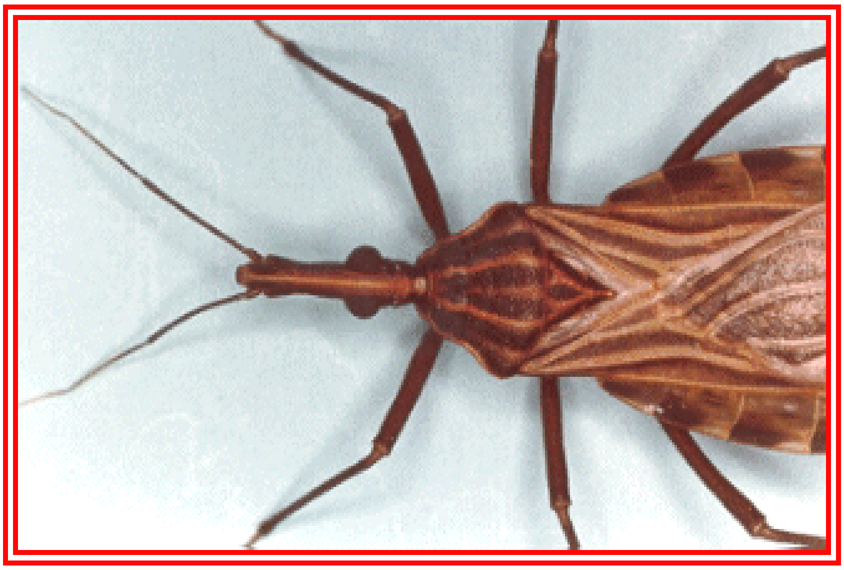
Graphic Images of Parasites

Rhodnius prolixus

Members of the genus *Rhodnius*, and the related genera *Panstrongylus* and *Triatoma*, serve as vectors for Chagas' disease (American trypanosomiasis).



Rhodnius prolixus. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)



Rhodnius prolixus. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Rhopalias sp.

A stained whole mount of an adult *Rhopalias* sp. recovered from an opossum. Note the presence of an armed (with hooks) proboscis on each side of the oral sucker. This is a characteristic of the family Rhopaliasidae.

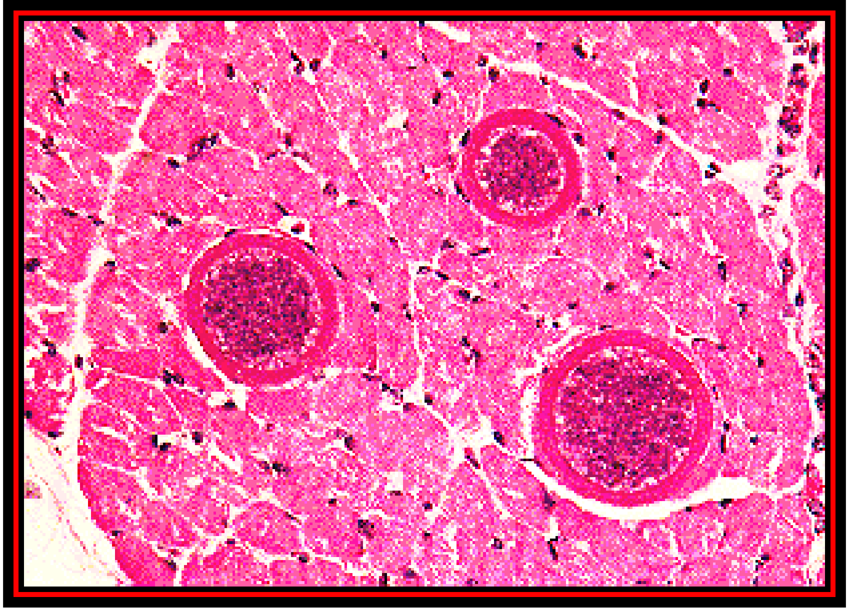
Another example of an adult *Rhopalias* sp.

Sarcocystis spp.

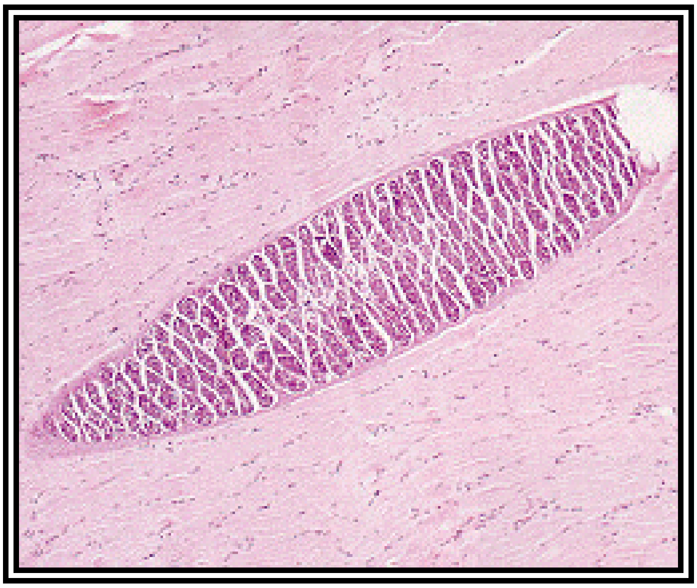
There are a number of species of *Sarcocystis*, all of which have obligate two host life cycles. In most instances the intermediate host is a hoofed animal, and many species of reptiles, birds and vertebrates will serve as the definitive host. For example, in *Sarcocystis cruzi*, the intermediate host is a cow, and the definitive host is a dog or other canine (view diagram of the life cycle). The intermediate host is infected when it ingests oocysts that have been passed in the definitive host's feces. The oocysts excyst in the intermediate host's small intestine, the parasites penetrate the surface of the intestine, and the parasites are distributed to tissues throughout the host's body. The cells of these tissues are infected, and the parasite reproduces asexually within the cells. This result in cells that are filled with parasites (these are called zoitocysts, sarcocysts, or Miescher's tubules), and the parasites within are called bradyzoites. The definitive host is infected with it ingests tissues (meat or prey) containing sarcocysts. In the definitive host the parasites infect the epithelium of the small intestine and reproduce asexually, eventually forming oocysts that are passed in the feces.

Infections of *Sarcocystis* in humans have been reported, but it is unclear if such infections are caused by a distinct species. It is also unknown if *Sarcocystis* infections in humans represent a serious health problem, and we really don't know how many people are infected since most infections are probably asymptomatic. This is fortunate considering that humans are likely exposed to *Sarcocystis* on a regular basis. In some areas of the world, a majority of cattle, sheep and pigs are infected with *Sarcocystis*, so meat from these animals could represent a source of human infections. A number of game animals also represent a potential source of infection. Cooking the meat will kill the bradyzoites.

Sarcocystis cruzi oocysts in the feces of an infected dog. (From: Gardiner *et al*., 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)



A section of tongue showing three sarcocysts. (From: Gardiner *et al*., 1988, An Atlas of Protozoan Parasites in Animal Tissues, USDA Agriculture Handbook No. 651.)



A sarcocyst of an unidentified species of *Sarcocystis* in the muscle of a human. (Original image from "Parasites in Human Tissues," Department of Parasitology, Kyungpook National University School of Medicine, Korea.)

Graphic Images of Parasites

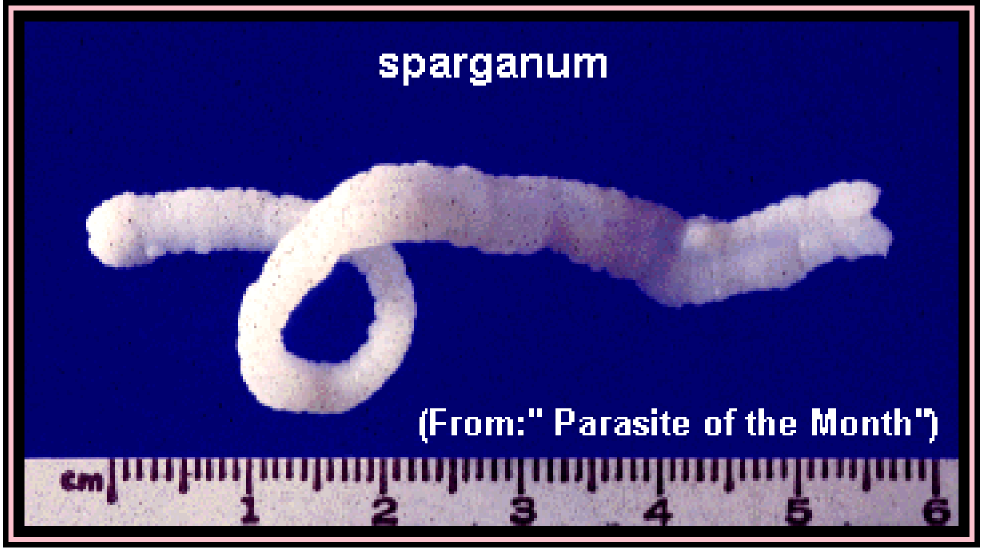
Sparganosis

Humans can serve as the intermediate host for several species of cestodes. For example, infections with cysticerci of *Taenia* cause cysticercosis, and infections with hydatid of *Echinococcus* cause hydatid disease. Humans can also served as the second intermediate host for some pseudophyllidean cestodes. In such cases the metacestode stage, normally called a plerocercoid, is called a sparganum, and the resulting infection is called sparganosis.

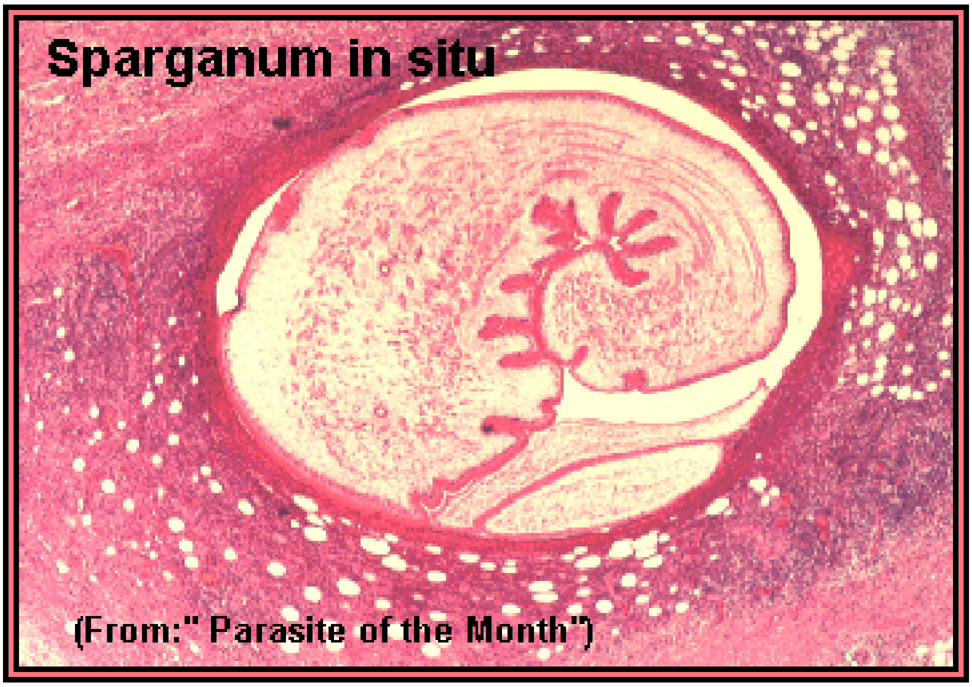
It is almost impossible to identify spargana to species, so it is unclear how many or which species of pseudophyllidean cestodes will infect humans. Humans can be infected by ingesting infected first intermediate hosts (e.g., infected copepods in drinking water) or infected second intermediate hosts (e.g., raw or undercooked amphibians, reptiles or mammals). Sparganosis has been reported from many countries of the world, but is most common in eastern Asia.

Once in the human host the spargana can migrate to virtually any part of the body and grow to be quite large (up to 14 inches or 5.5 cm). The pathology associated with sparganosis depends on the number and size of spargana and the organs involved. Infections consisting of one or two spargana in the deep muscles might cause no overt symptoms and go undiagnosed. Infections in the eye can result in blindness, while infections of subdermal tissues can result in painful "lumps" that might be misdiagnosed as cancer (see below).

A sparganum recovered from a "lump" in the breast of a female patient suspected of having breast cancer.



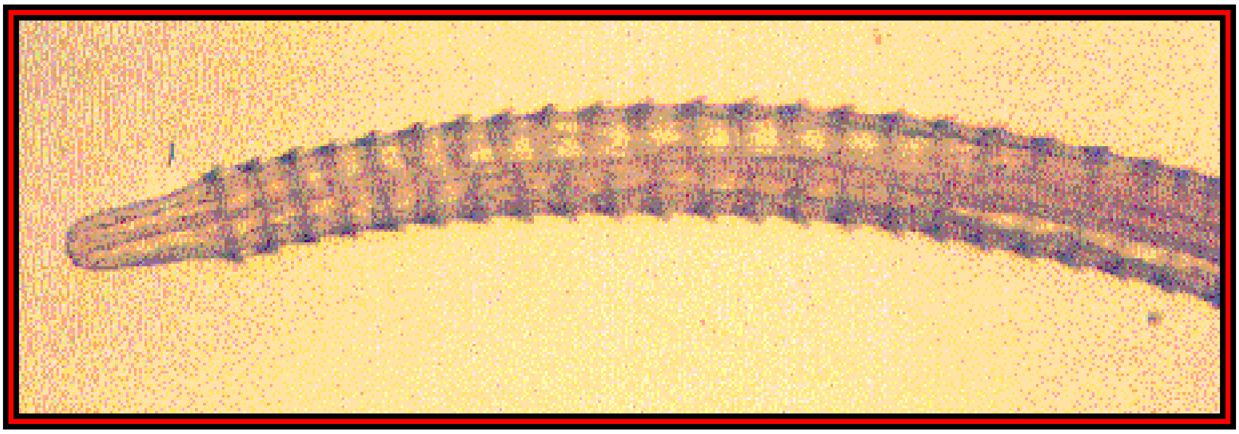
The entire sparganum recovered from the above patient.



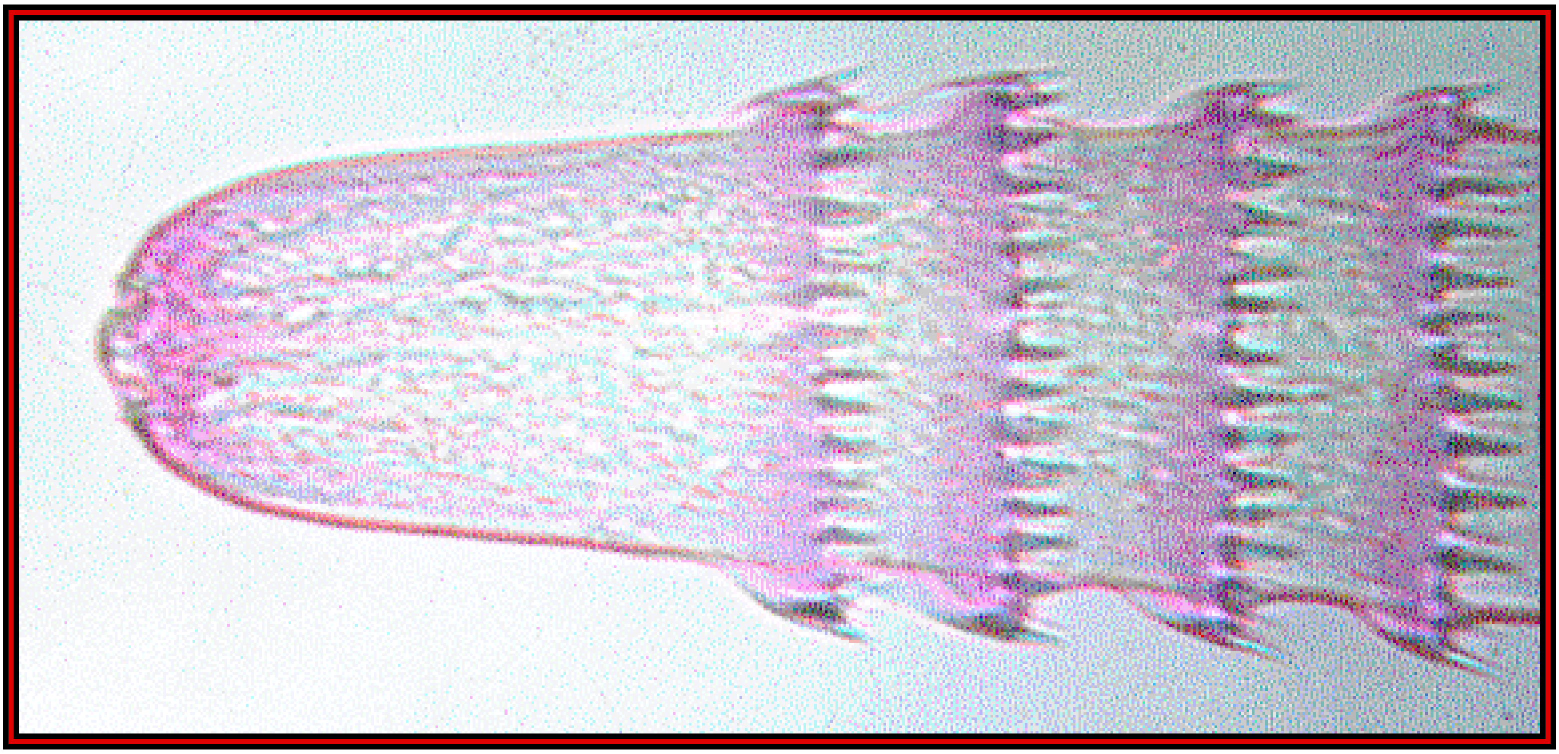
A histological section containing a sparganum. Note the intense host response around the metacestode.

Graphic Images of Parasites

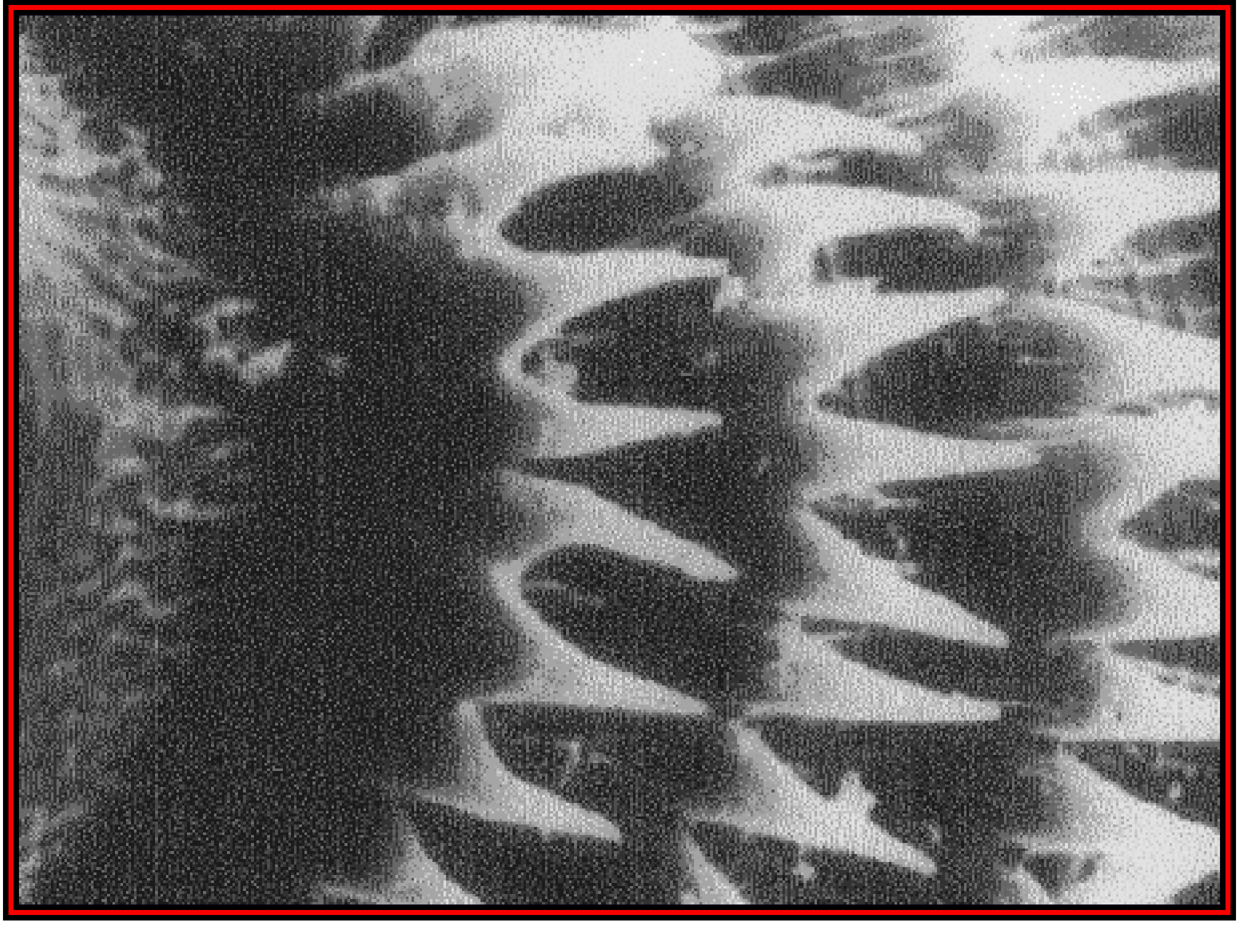
Spinitectus sp.



The anterior end of an adult *Spinitectus* sp. recovered from a sunfish. Note the transverse rings around the worm, a characteristic feature.



A higher power view of the anterior end of an adult of *Spinitectus*.



A scanning electrom micrograph of the transverse rings.

Graphic Images of Parasites

Strongyloides stercoralis

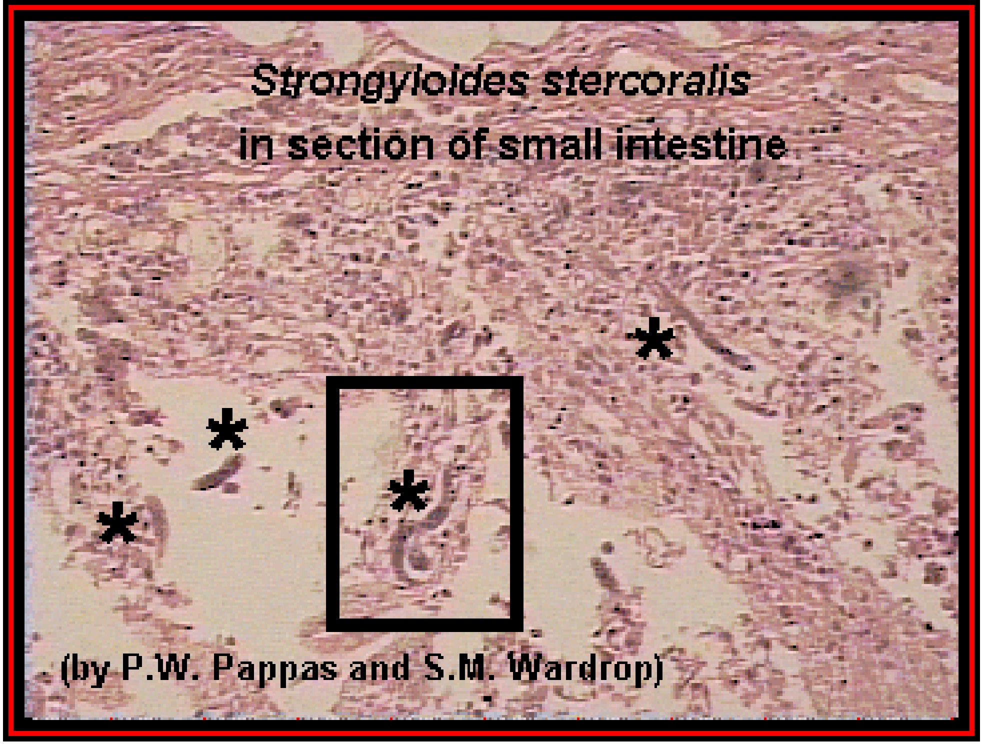
Strongyloides stercoralis is an unusual "parasite" in that it has both free-living and parasitic life cycles. In the parasitic life cycle, female worms are found in the superficial tissues of the human small intestine; there are apparently no parasitic males. The female worms produce larvae parthenogenically (without fertilization), and the larvae are passed in the host's feces. The presence of nematode larvae in a fecal sample is characteristic of strongylodiasis. Once passed in the feces, some of the larvae develop into "free-living" larvae, while others develop into "parasitic" larvae. The "free-living" larvae will complete their development in the soil and mature into free-living males and females. The free-living males and females mate, produce more larvae, and (as above) some of these larvae will develop into "free-living" larvae, while other will develop into "parasitic larvae." As one might imagine, this free-living life cycle constitutes an important reservoir for human infections.

The "parasitic" larvae infect the human host by penetrating the skin (like the hookworms). The larvae migrate to the lungs, via the circulatory system, penetrate the alveoli into the small bronchioles, and they are "coughed up" and swallowed. Once they return to the small intestine, the larvae mature into parasitic females.

S. stercoralis also infects humans via a mechanism called "autoinfection." Under some circumstances, such as chronic constipation, larvae produced by the parasitic females will remain in the intestinal tract long enough to develop into infective stages. Such larvae will penetrate the tissues of the intestinal tract and develop as if they had penetrated the skin. Autoinfection can also occur when larvae remain on and penetrate the perianal skin. Autoinfection often leads to very high worm burdens in humans (view diagram of the life cycle).

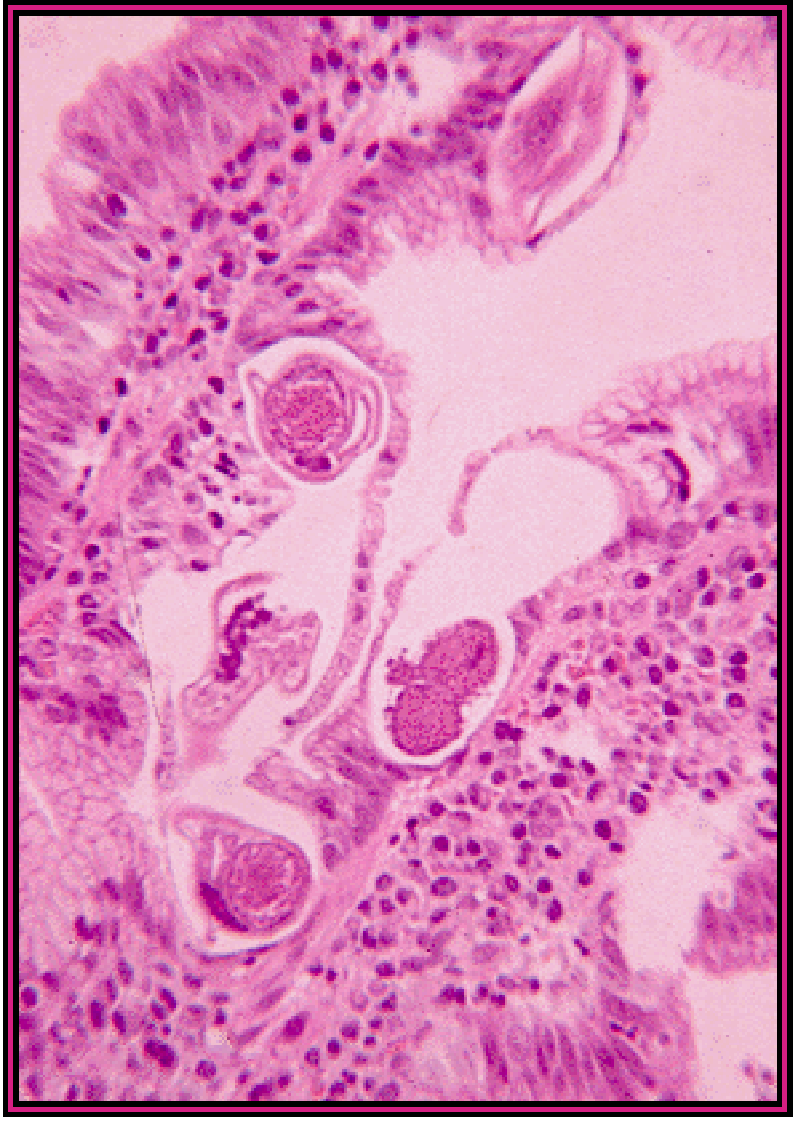
Since the parasitic females live in the superficial tissues of the small intestine, and can be present in high numbers, they can cause significant pathology.

Strongyloides stercoralis in the wall of the small intestine; numerous adults are visible in this section, as is the abnormal appearance of the intestinal mucosa.

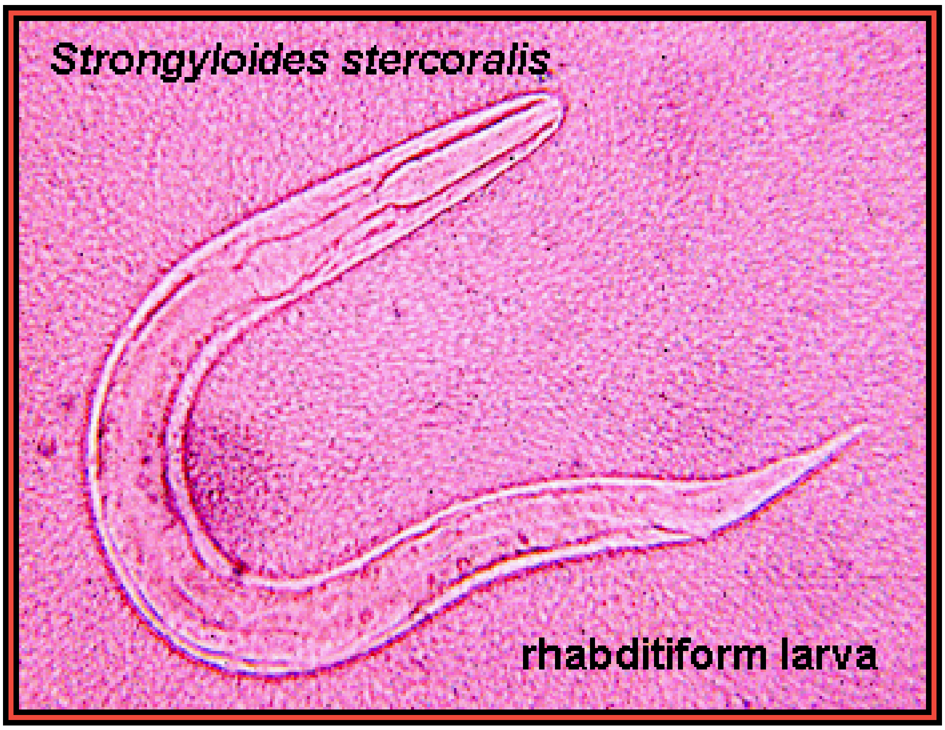


A higher power magnification of the above image; the adult worms are labeled (*), and a higher power magnification of the enclosed area is shown in the following image.

An enlargement of the enclosed area in the above image.



Strongyloides stercoralis adults in the small intestine. (From "Parasite of the Month.")



Strongyloides stercoralis larva as it would appear in a fecal sample. Note the rhabditiform esophagus. (From "Parasite of the Month.")

Another example of the larva in which the rhabditiform esophagus shows up clearly. (Original image from "Atlas of Medical Parasitology.")

Graphic Images of Parasites

Styphlodora sp.

The two images below are the anterior and posterior aspects of an adult *Styphlodora* sp. recovered from an indigo snake.

Taenia spp.

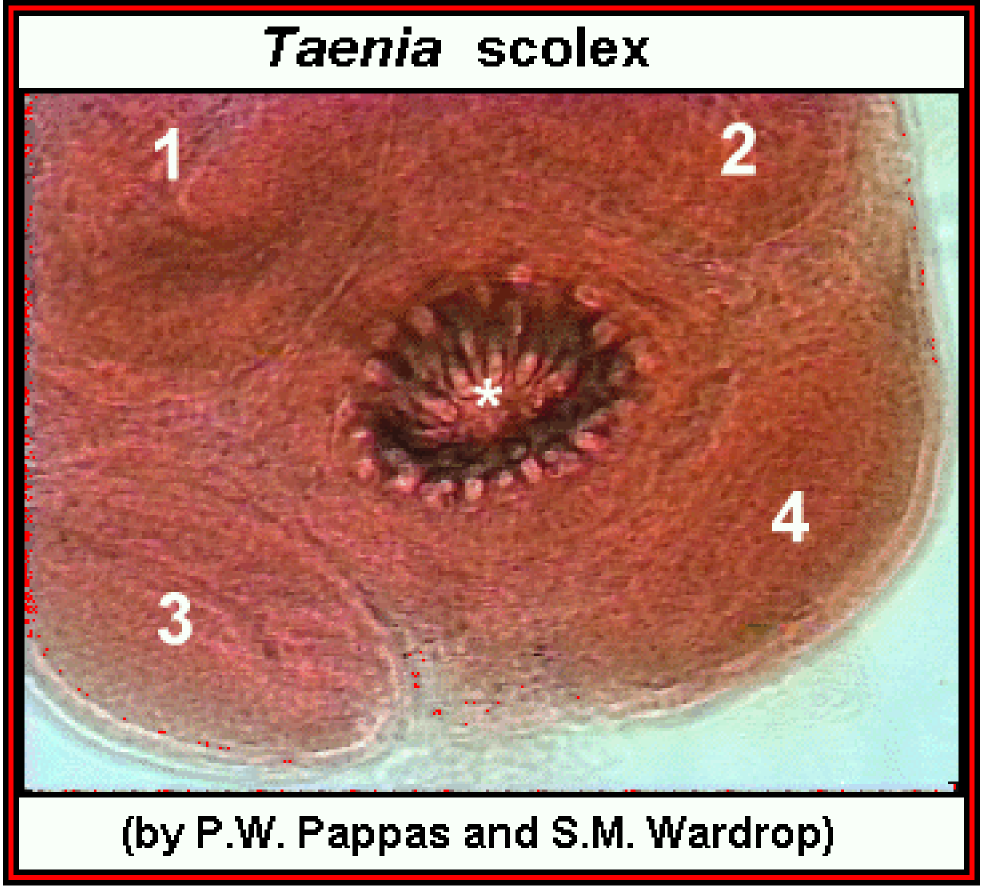
There are several species of *Taenia* that humans are likely to encounter. These include two species for which humans serve as the definitive host: *Taenia saginata* (now often called *Taeniarhynchus saginatus*), the beef tapeworm; and *T. solium*, the pork tapeworm. Several species of *Taenia* also infect dogs and cats (e.g.,*T. pisiformis*), and humans are likely to encounter these when they note the presence of these tapeworms' proglottids in their pets' feces.

All species of *Taenia* have similar life cycles. The adult tapeworm lives in the definitive host's small intestine. Proglottids, which contain eggs, break off the posterior end of the tapeworm, and these proglottids are either passed intact in the host's feces or they dissolve in the host's intestine and eggs are passed in the feces. The eggs of *Taenia* have a characteristic appearance (see below), but they can not be differentiated to species. The intermediate host is infected when it ingests the eggs, and a cysticercus develops in the intermediate host. The definitive host is infected when it eats an intermediate host infected with cysticerci (view diagram of the life cycle). As adults in the definitive host's small intestine, tapeworms rarely cause problems; in exceptional cases the tapeworms might physically block the intestinal tract, due to their large size, or proglottids might become lodged in the appendix and result in appendicitis. The proglottids of *Taenia* are large and muscular. Occasionally single proglottids or long chains of proglottids might crawl out of the anus of an infected human. Understandably, most humans would find this quite disturbing, and it surely would not be an appropriate topic for "polite conversation."

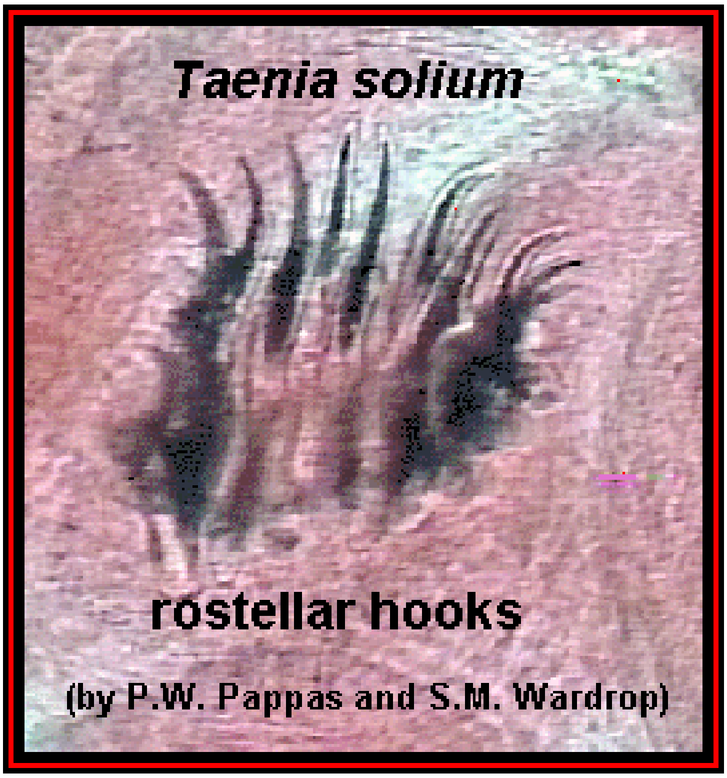
Although adult tapeworms in humans rarely cause problems, humans can also be infected with cysticerci. Such an infection is referred to as cysticercosis, and this can result in significant pathology.

Infections with *Taenia* are diagnosed by recovering eggs or proglottids in the feces of an infected host. The eggs of *T. saginata* and *T. solium* are virtually identical, but these two species can be differentiated based on the morphology of their proglottids and scolex (holdfast). However, since the same drugs are used for treating both species, such differentiation is generally unnecessary. The proglottids of canine and feline species of *Taenia* are rectangular and larger than those of *Dipylidium caninum*, thus making differentiation of these species relatively simple.

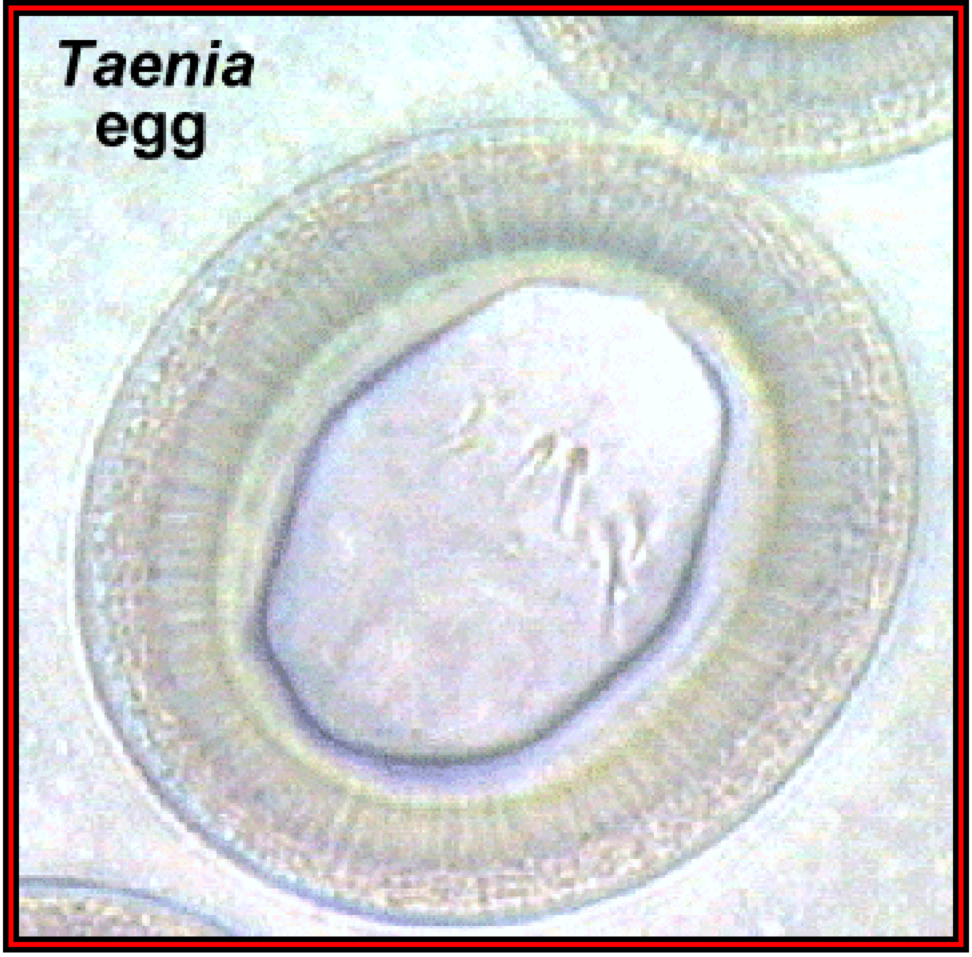
If you are interested in more detailed information about the species of *Taenia* infecting humans, dogs, and cats, click here.



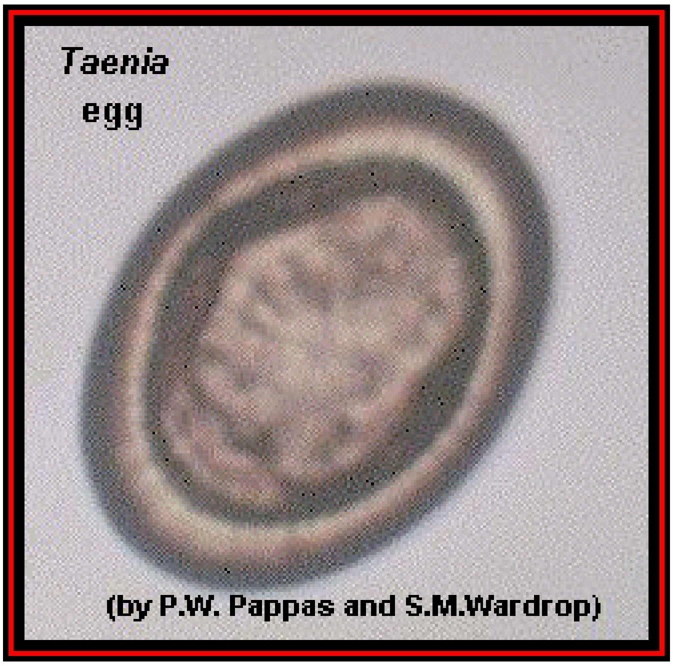
A stained whole mount of the scolex (holdfast) of *Taenia solium*, the pork tapeworm; the scolex measures approximately 1 mm across. The four suckers are numbered. Note the presence of an armed (hooked) rostellum (*); the scolex of *Taenia saginata*, the beef tapeworm, does not have an armed rostellum.



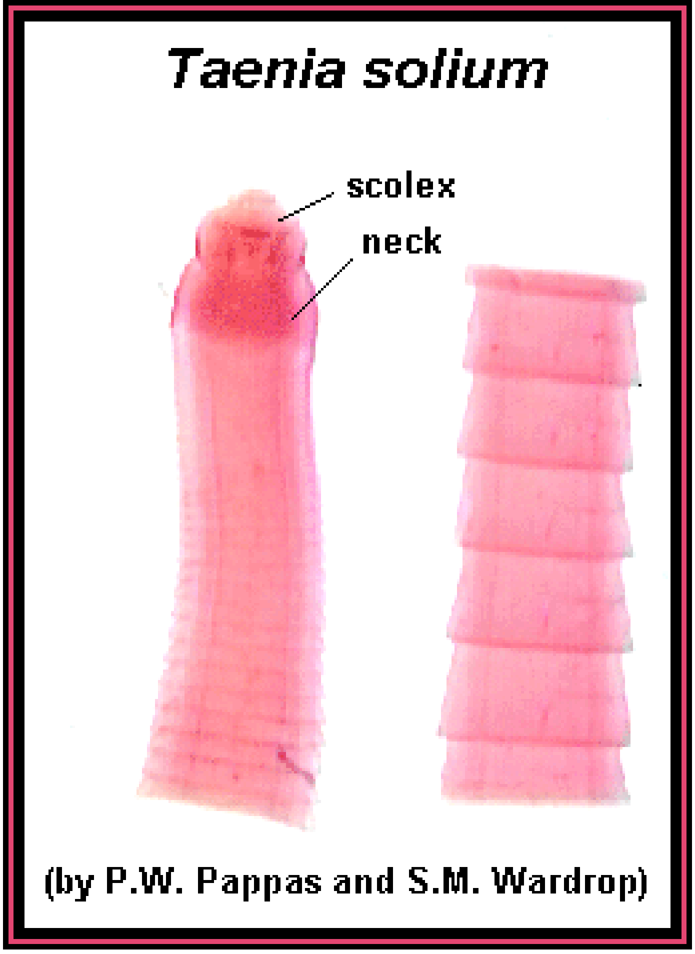
A stained whole mount of the scolex of *Taenia solium*. The scolex was crushed when this preparation was made to emphasize the shape of the rostellar hooks.



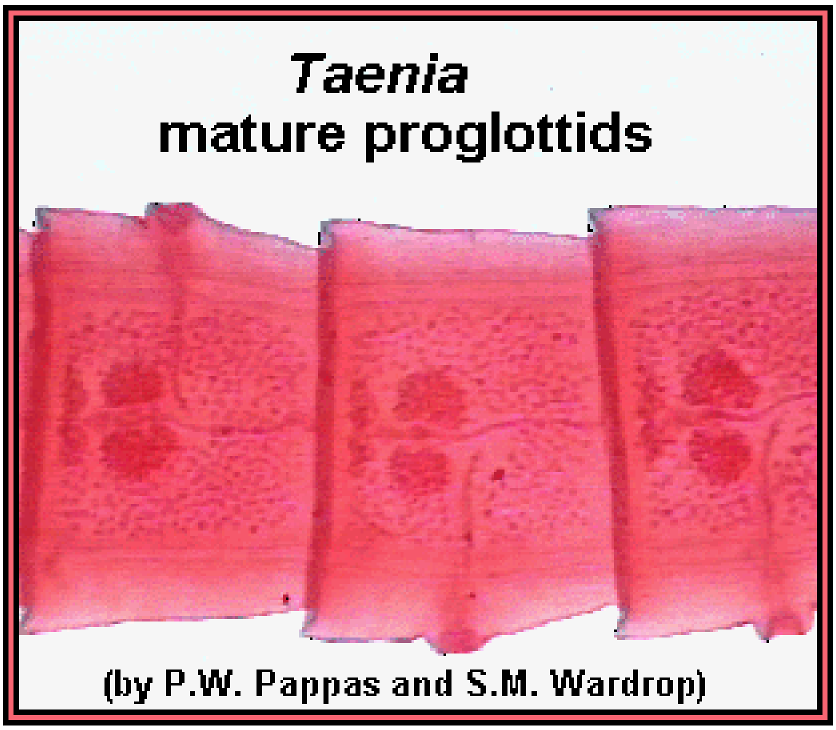
Taenia egg. Note the thick, "striated" shell and several of the larval hooks; approximate size = 40 µm. Eggs of all species of *Taenia* look like this example. (Original image from "Atlas of Medical Parasitology.")



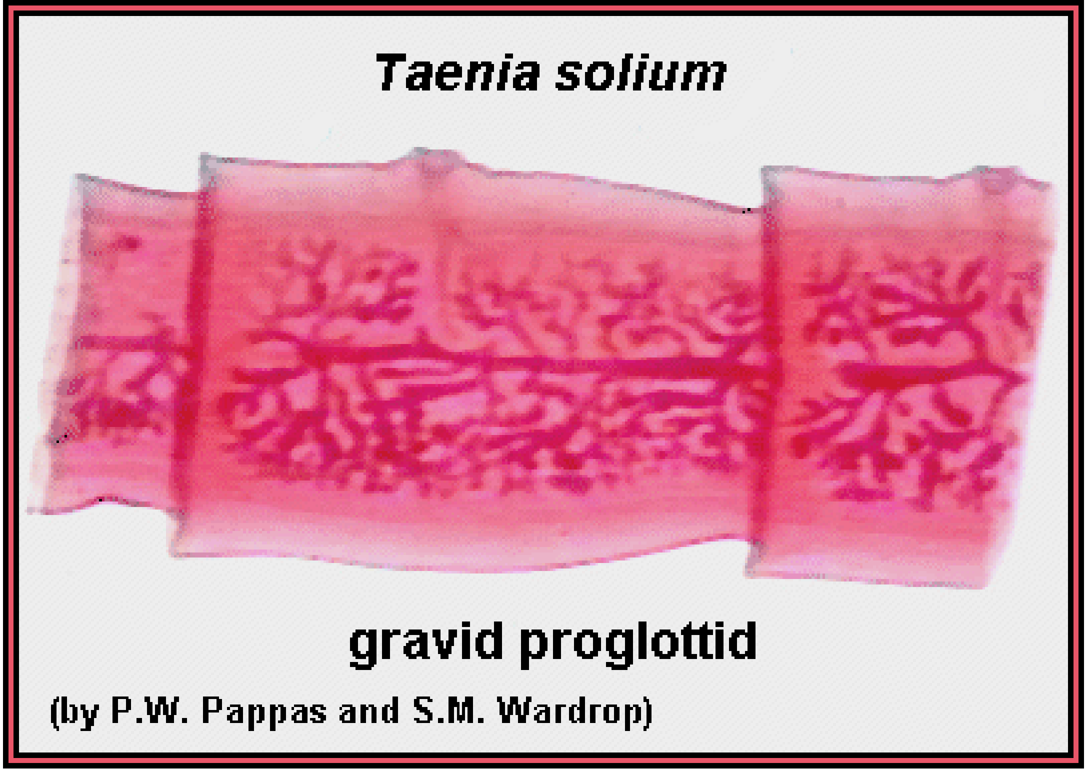
Another example of a *Taenia* egg showing the thick (striated) "shell." (Original image from Oklahoma State University, College of Veterinary Medicine.)



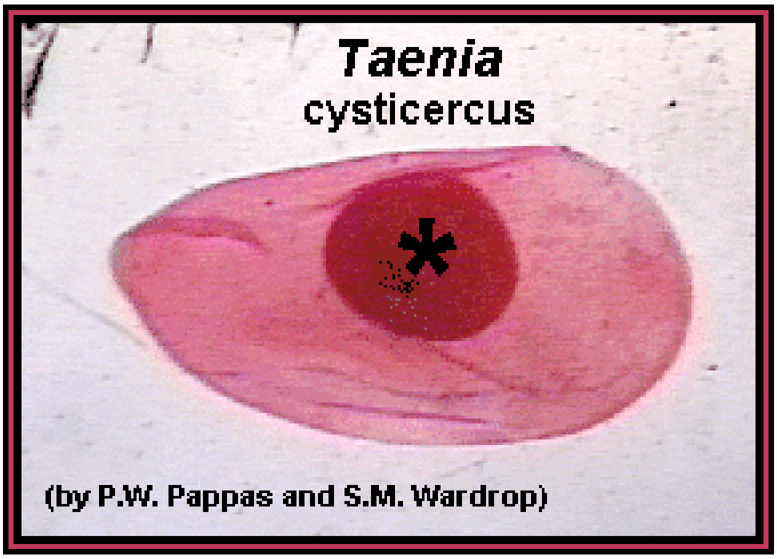
Anterior region of *Taenia solium* showing the scolex and neck region. The proglottids on the right are immature; note that the reproductive organs are just beginning to differentiate.



Mature proglottids of *Taenia* sp.; each proglottid measures about 4 mm in length. Click here to view an image in which the characteristic features are labeled.)



A gravid proglottid of *Taenia solium*. In this species the uterus of the gravid proglottid has between 7 and 13 lateral branches on each side. In *T. saginata* the uterus of the gravid proglottid has between 15 and 20 lateral branches on each side.



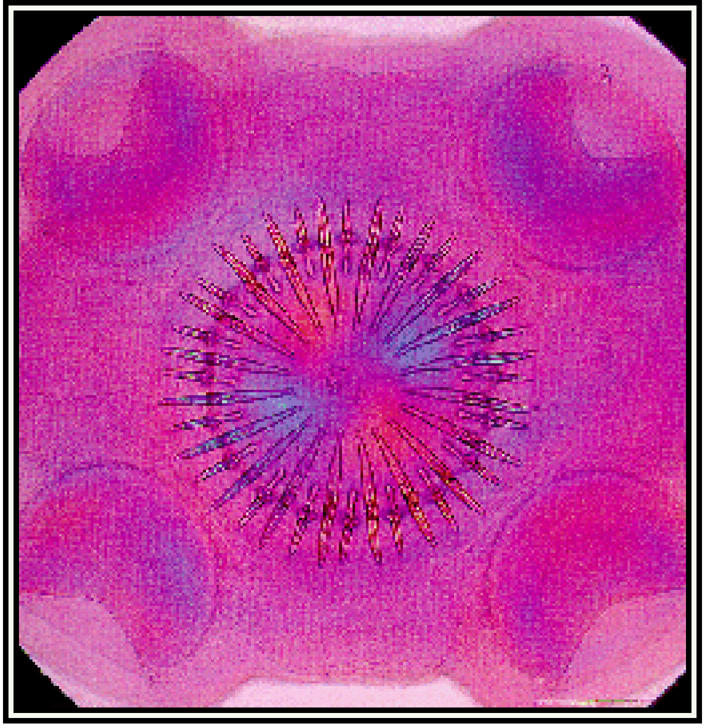
A cysticercus (stained whole mount) of *Taenia* sp. The cysticercus consists of scolex or holdfast (*) within a large "bladder;" hence, cysticerci are often referred to a "bladder worms." This cysticercus measures approximately 5 mm across.

A cysticercus of *Taenia* in muscle. Note the fibrous capsule (*) around the cysticercus.

Taenia pisiformis

Dogs serve as the definitive host for this species of cyclophyllidean cestode, and rabbits most often serve as the intermediate host. The life cycle stage found in the intermediate host is a cysticercus. Dog owners often encounter this parasite when the proglottids are passed in the stools of their pet. The proglottids of this species can be differentiated from the other common tapeworm of dog, *Dipylidium caninum*, in that the proglottids of this species are distinctly rectangular and much larger than those of *D. caninum*. Many aspects of the biology of this species are similar to other species of *Taenia*.

A stained whole mount of the scolex of *Taenia pisiformis*, a common parasite of dogs.



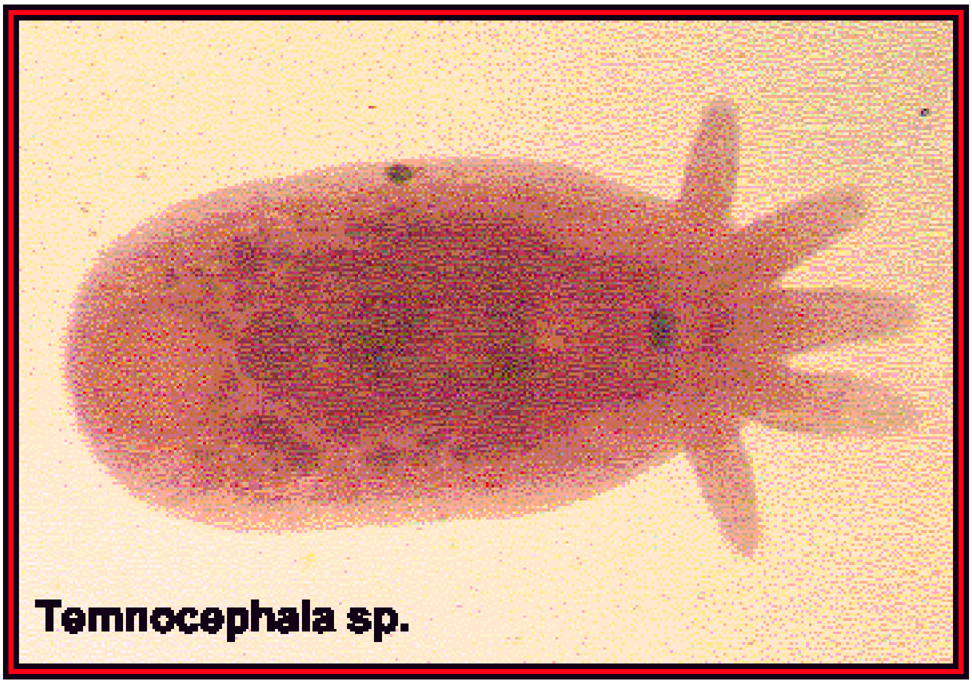
An *en face* view of the scolex of *Taenia pisiformis* showing the four suckers and hooks. (Original image from F. Rochette, 1999, *Dog Parasites and Their Control*, Janssen Animal Health, B.V.B.A. and used with permission.)

Telorchis sp.

The two images below are the anterior and posterior aspects of an adult *Telorchis aculeatus*. The position of the testes (posterior-most region of the body) is characteristic of the family Telorchiidae.

Temnocephala sp.

Temnocephalids are primitive flatworms, characterized by the presence of anterior tentacles and a posterior sucker. Most of them are ectocommensals on the surfaces of various species of crustacea. The life cycles of these organisms are very simple. The adult worm lays (or attaches) eggs to the host's surface, and the egg hatches producing an immature worm. The worm simply attaches to the host's surface and matures sexually.



A stained whole mount of *Temnocephala* sp. The "tentacles" are at the anterior end, and the outline of the posterior sucker is just visible.

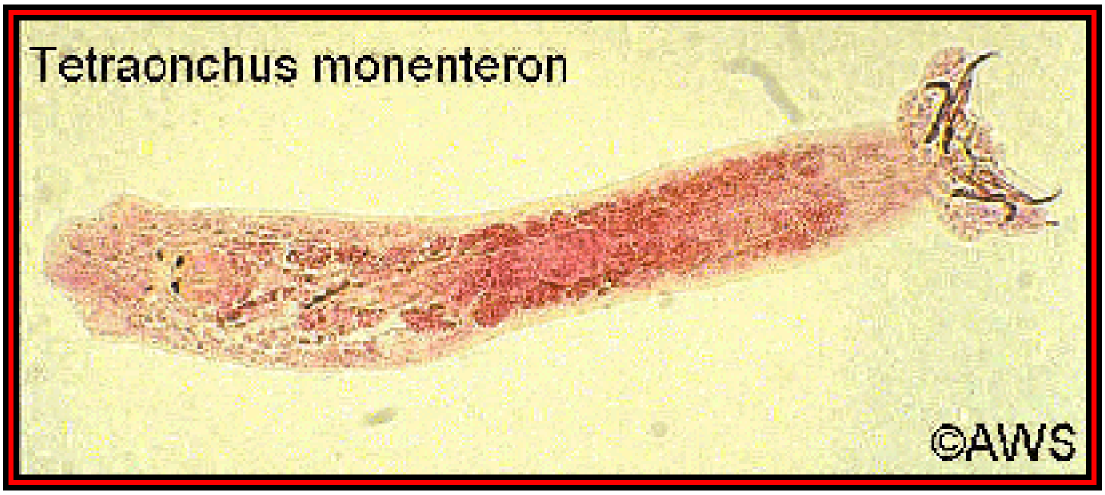
Tenebrio molitor
(yellow mealworms)

Tenebrio molitor is one of the largest "pests" found in stored grain products. The adults are approximately 20 mm in length, and larvae (mealworms) can measure up to 30 mm in length. The adult beetles can serve as the intermediate host for several species of parasites, including *Hymenolepis* spp.

Tenebrio molitor adult

Tenebrio molitor larvae (mealworms).

Tetraonchus sp.



A whole mount of *Tetraonchus menenteron*. Note the large anchors (hooks) on the opisthaptor (right side of image). Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Graphic Images of Parasites

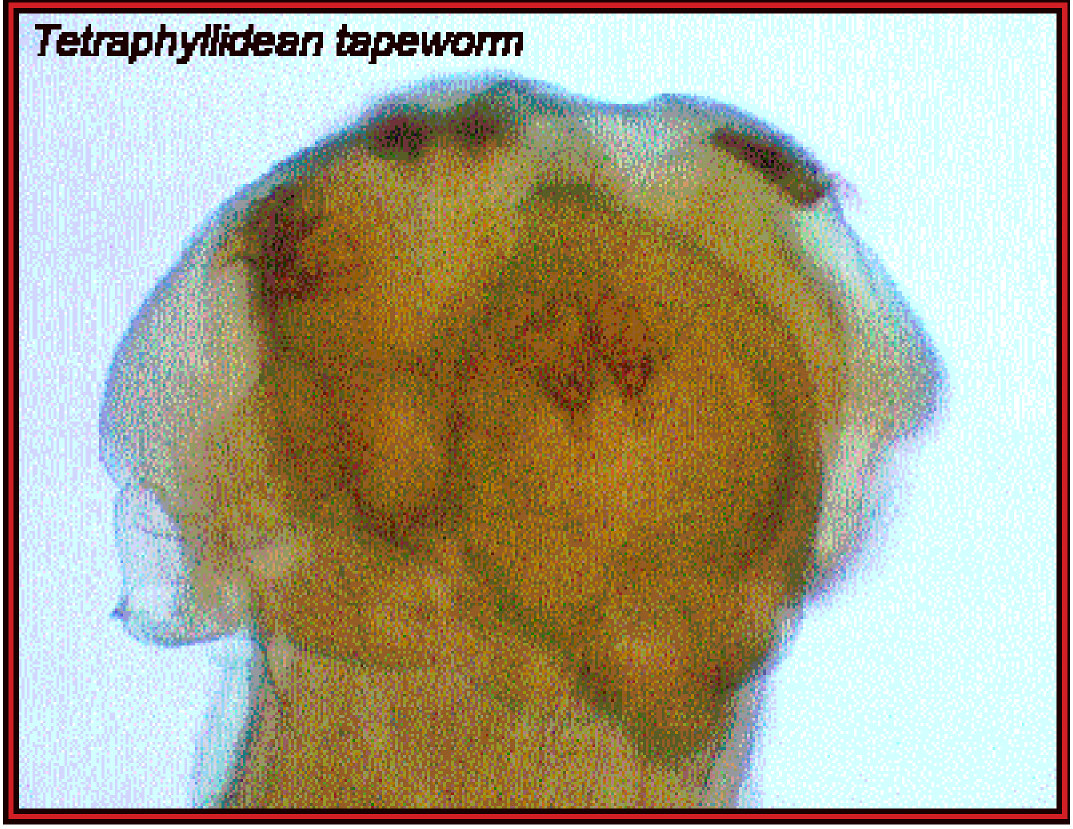
Order Tetraphyllidea

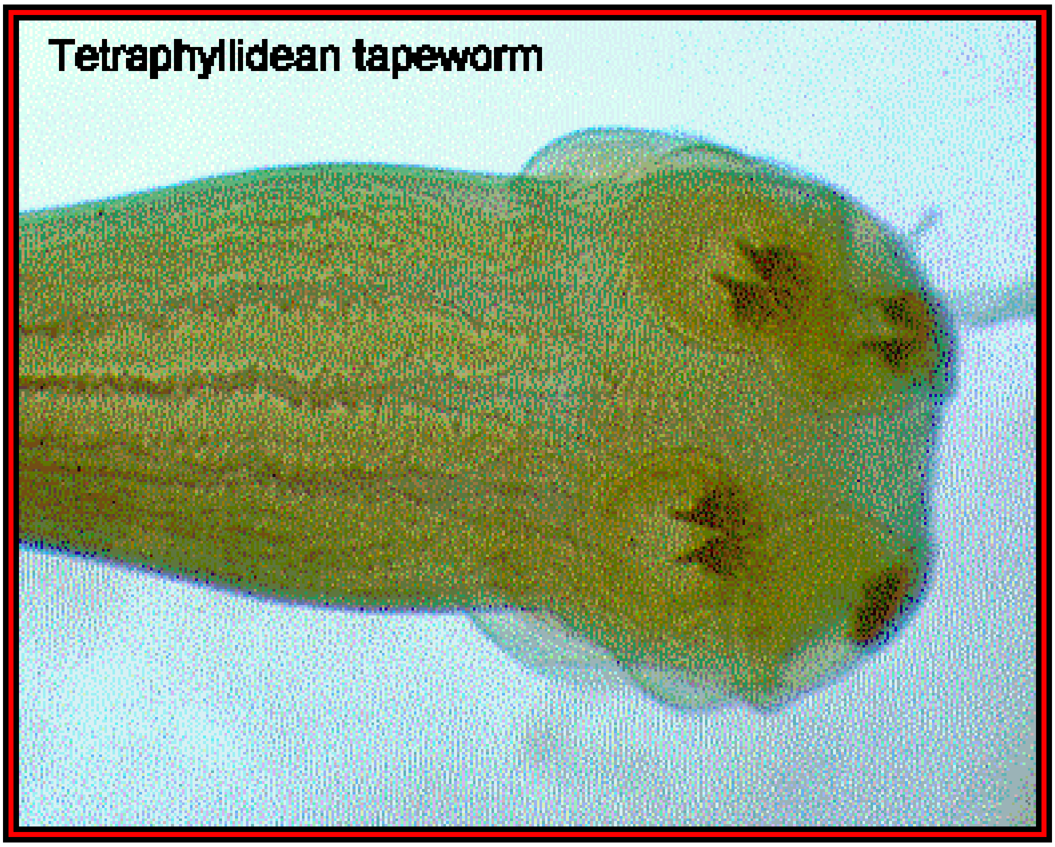
(the tetraphyllidean tapeworms)

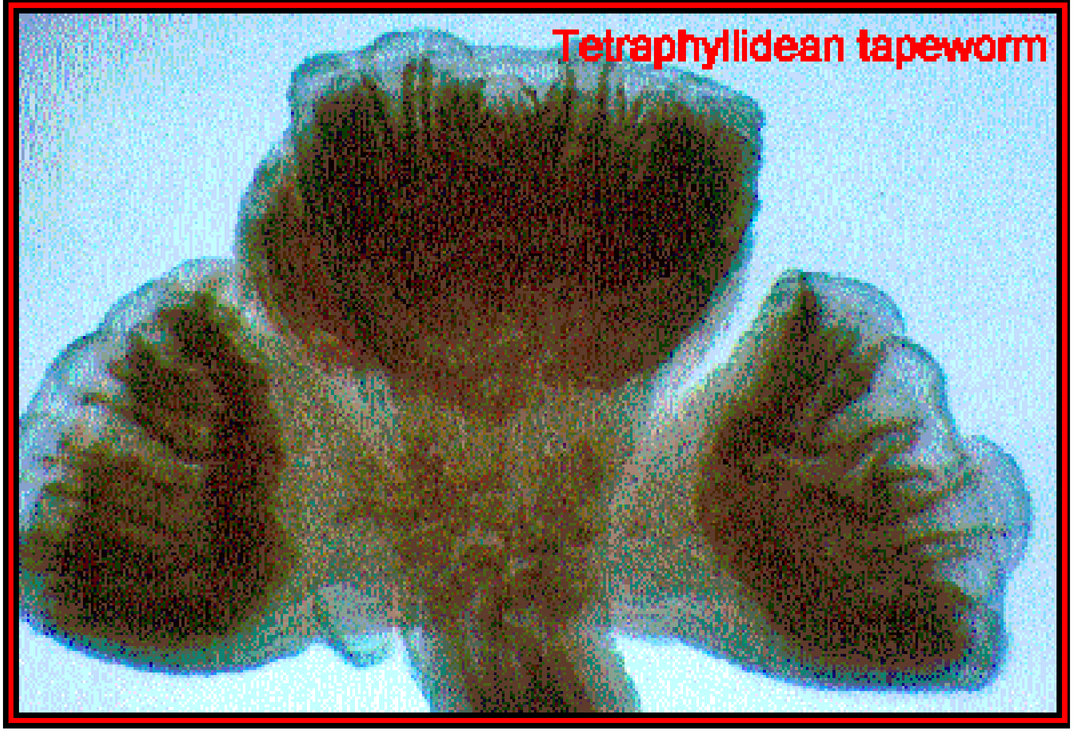
The tetraphyllidean cestodes are parasites of the spiral valves (intestines) of elasmobranchs (sharks and rays). The life cycles of these organisms are not known. The scoleces (holdfasts) of the Tetraphyllidea are arguably the most complex and diverse among the tapeworms. The scoleces may contain some combination of large suckers, which may be on the ends of large stalks and/or subdivided into loculi, smaller accessory suckers, and/or hooks. Much of the taxonomy of this group is based on the morphology of the scolex.

The following four images are the scoleces of different species of tetraphyllidean cestodes. Note the differences in the appearance of the scoleces, and that some have accessory hooks.

Anthobothrium sp.


Tetraphyllidean tapeworm


Tetraphyllidean tapeworm

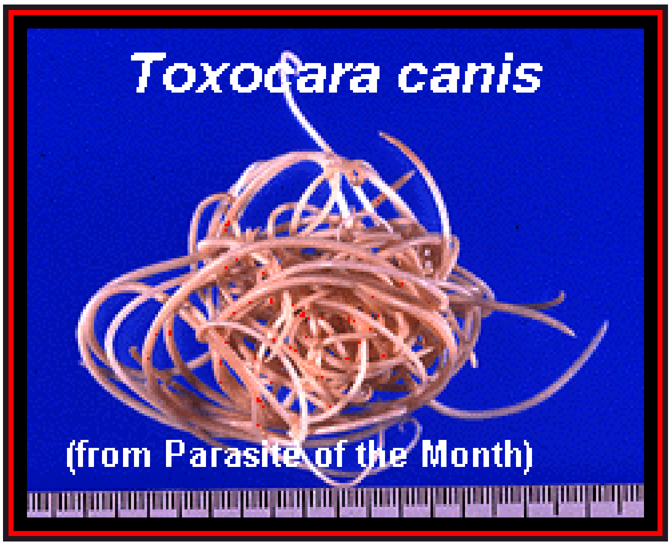

Tetraphyllidean tapeworm

Toxocara canis

(intestinal roundworm of dogs)

The life cycle of *Toxocara canis*, a common roundworm of dogs, is similar to that of *Ascaris lumbricoides*, but with a few additional frills. Assuming a dog has never been infected with *Toxocara*, the first time it is infected the worms develop as described for *Ascaris*. If a dog has been infected previously and ingests infective eggs, most of the larvae that hatch from the eggs do NOT develop into adults. Rather, they remain in the dog's tissues as "second stage somatic larvae." If these second stage somatic larvae are in a female and she gets pregnant, transplacental infection of the fetus will occur. This explains why, in some areas, up to 95% of puppies are born with infections of *Toxocara canis*. If another animal, such as a rodent, eats infective eggs of *Toxocara*, second stage somatic larvae will develop in this animal. If a dog then eats this animal, the dog gets infected. Humans can also be infected with second stage somatic larvae of *Toxocara canis*, as well as the larvae of other species of nematodes, resulting in a condition known as visceral larval migrans or VLM. The eggs of *Toxocara* are extremely resistant to adverse environmental conditions, and, once an area is contaminated with eggs (such as a playground, park, or your yard), its very difficult to sanitize the area. **Thus, it's very important that dogs be checked for this parasite on a regular basis, and that dog's not be permitted to defecate indiscriminately**.

Intestinal infections of *Toxocara canis* in dogs are diagnosed by finding characteristic eggs in the feces of the infected host. Infections of hosts with second stage somatic larvae of this parasite are more difficult to detect, and many probably go undiagnosed.



Toxocara canis adults.

An egg of *Toxocara canis*. Ingestion of these eggs by a human can result in visceral larval migrans.


An egg of *Toxascaris leonina*. This parasite is found in dogs and cats, but apparently will not cause visceral larval migrans in humans. (Original image from Oklahoma State University, College of Veterinary Medicine.)

	Alphabetical Listing	
	Taxonomic Listing	
	Home Page	

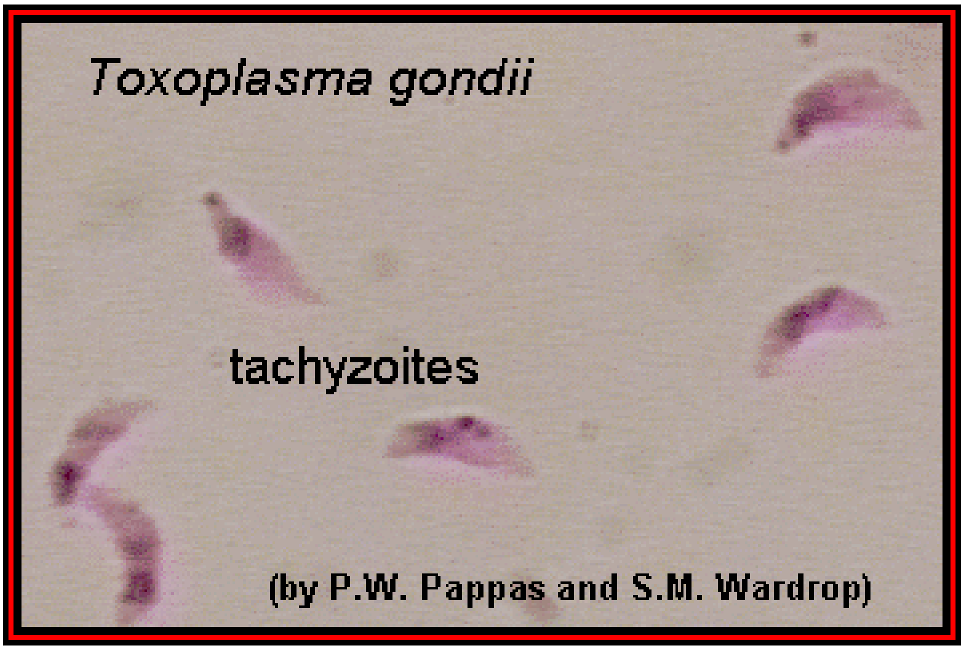
Graphic Images of Parasites

Toxoplasma gondii
(toxoplasmosis)

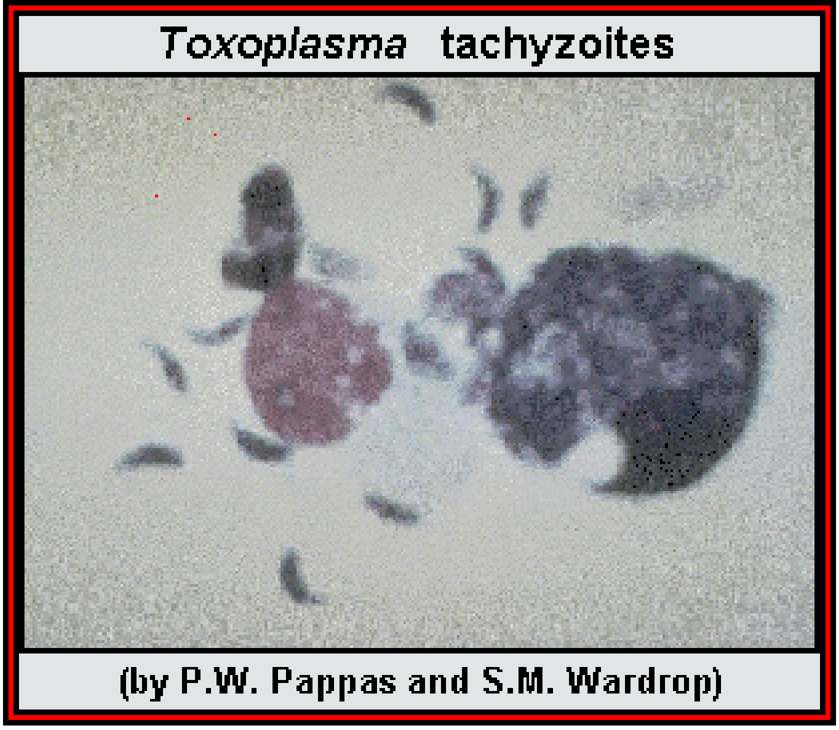
Toxoplasma gondii has very low host specificity, and it will probably infect almost any mammal. It has also been reported from birds, and has been found in virtually every country of the world. Like most of the Apicomplexa, *Toxoplasma* is an obligate intracellular parasite. Its life cycle includes two phases called the intestinal (or enteroepithelial) and extraintestinal phases. The intestinal phase occurs in cats only (wild as well as domesticated cats) and produces "oocysts." The extraintestinal phase occurs in all infected animals (including cats) and produces "tachyzoites" and, eventually, "bradyzoites" or "zoitocysts." The disease toxoplasmosis can be transmitted by ingestion of oocysts (in cat feces) or bradyzoites (in raw or undercooked meat) (view a diagram of the life cycle). Several of these life cycle stages are shown below.

In most humans infected with *Toxoplasma*, the disease is asymptomatic. However, under some conditions, toxoplasmosis can cause serious pathology, including hepatitis, pneumonia, blindness, and severe neurological disorders. This is especially true in individuals whose immune systems are compromised (e.g., AIDS patients). Toxoplasmosis can also be transmitted transplacentally resulting in a spontaneous abortion, a still born, or a child that is severely handicapped mentally and/or physically.

You can find additional information on *Toxoplasma* here.

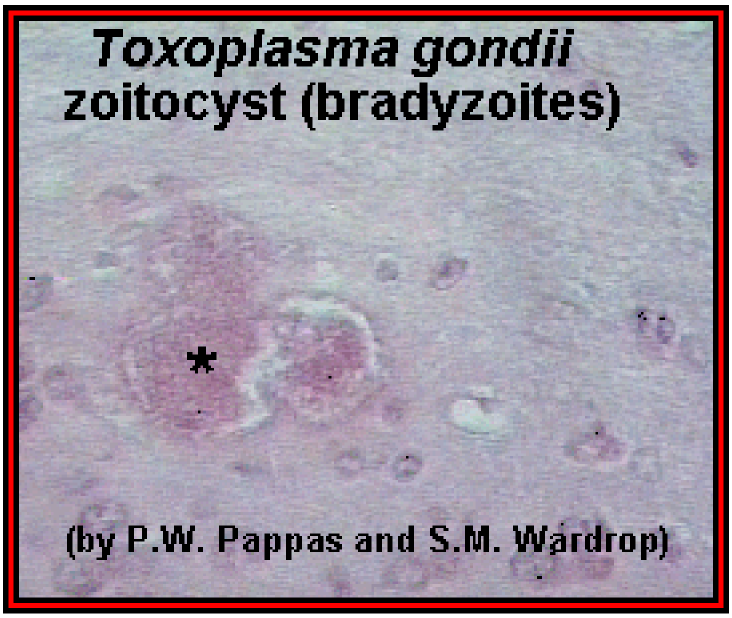


Tachyzoites of *Toxoplasma gondii*. Note the characteristic crescent shape. Although this is an intracellular stage, the cells containing the tachyzoites (macrophages) were broken open when the slide was prepared. Each tachyzoite measures approximately 10 µm in length.

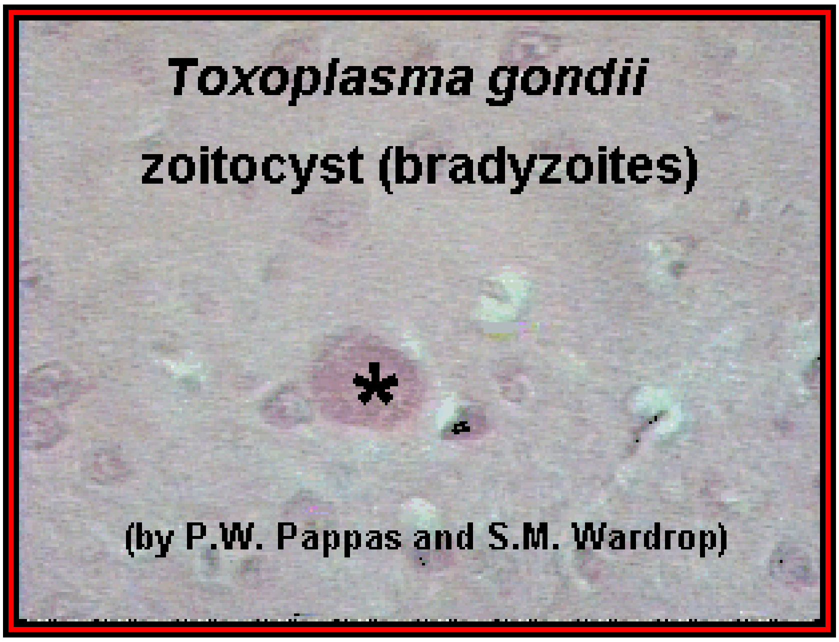


Another example of *Toxoplasma gondii* tachyzoites. (Original image from Oklahoma State University, College of Veterinary Medicine.)

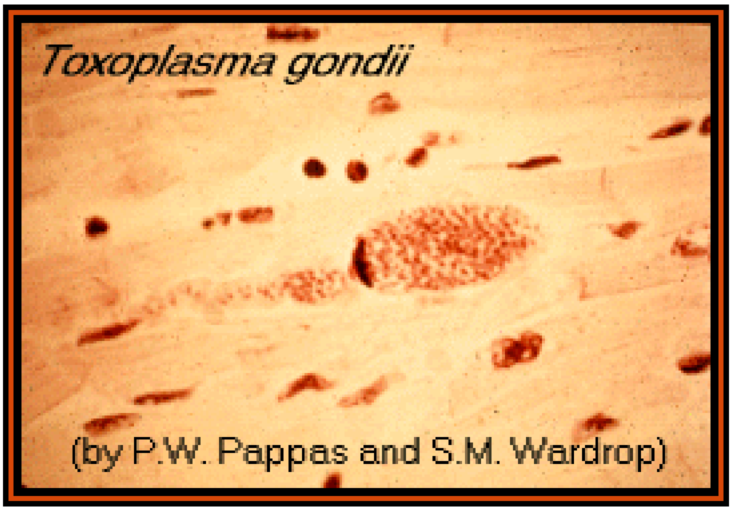
Intracellular tachyzoites of *Toxoplasma gondii*. (Original image from "Parasites in Human Tissues," Department of Parasitology, Kyungpook National University School of Medicine, Korea.)



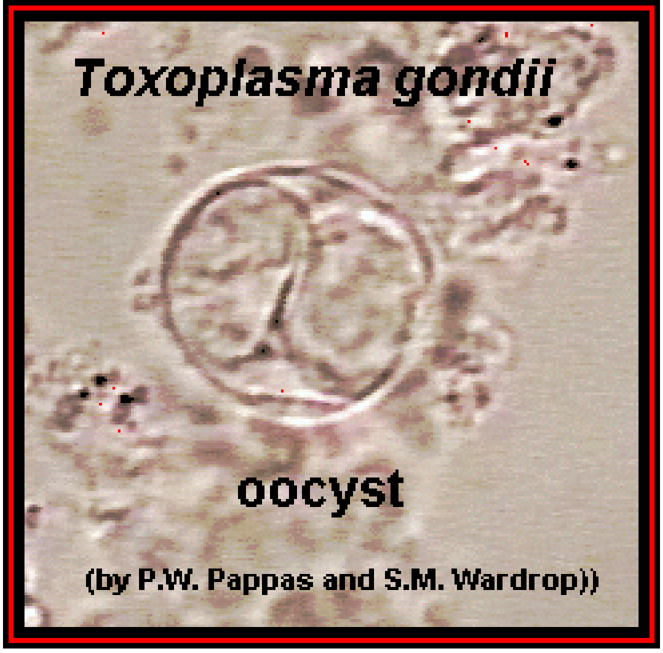
Toxoplasma gondii bradyzoites (*) in a tissue section of the brain of an experimentally infected mouse. This life cycle stage is found during the chronic stage of the infection, and it can be found in almost any organ of the body.



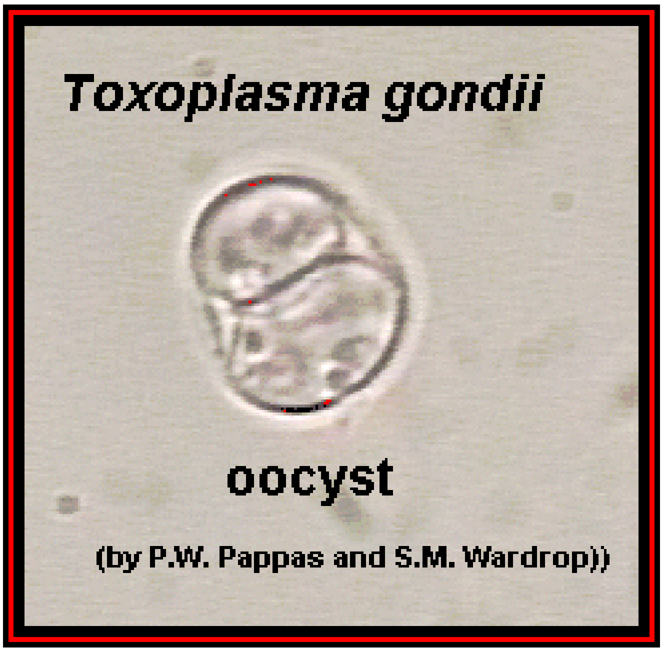
Toxoplasma gondii bradyzoites (*) in a tissue section of the brain of an experimentally infected mouse.



A zoitocyst of *Toxoplasma gondii* filled with bradyzoites; this zoitocyst is in cardiac muscle.



A sporulated oocyst of *Toxoplasma gondii*. The oocyst contains two sporocysts, each of which contain four sporozoites. Thus, they resemble the oocysts of *Isospora* sp. Only cats will produce and pass *Toxoplasma* oocysts; approximate diameter = 10 µm.

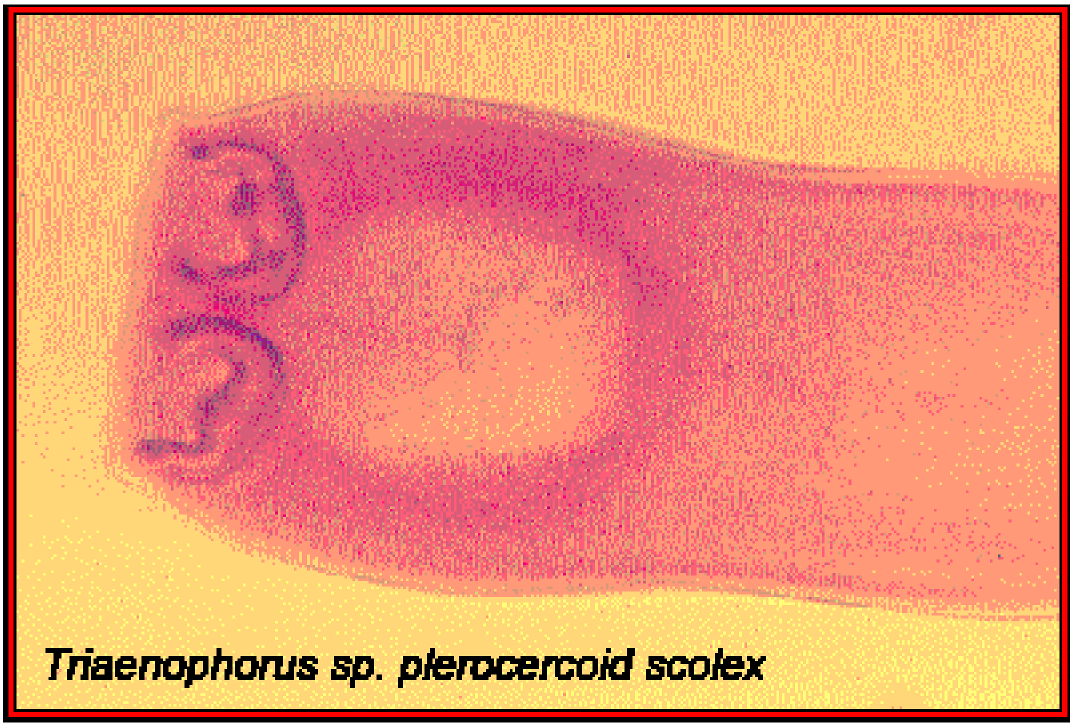


A sporulated oocyst of *Toxoplasma gondii*; see Legend for above figure.

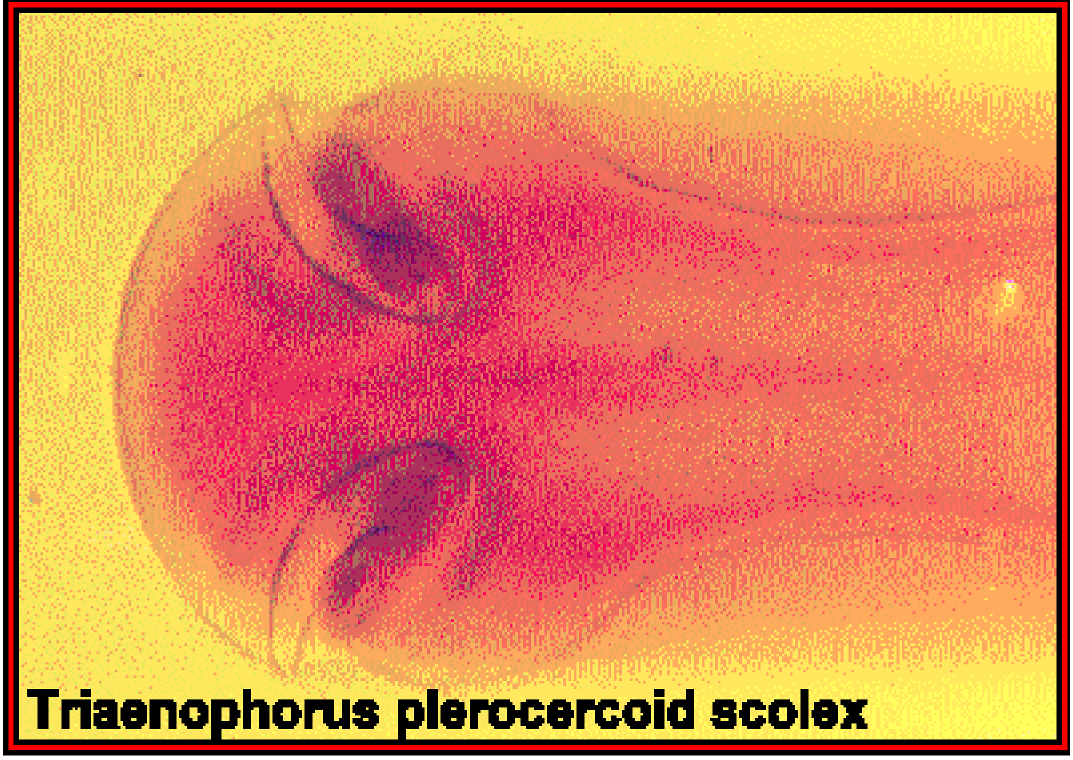
Triaenophorus sp.

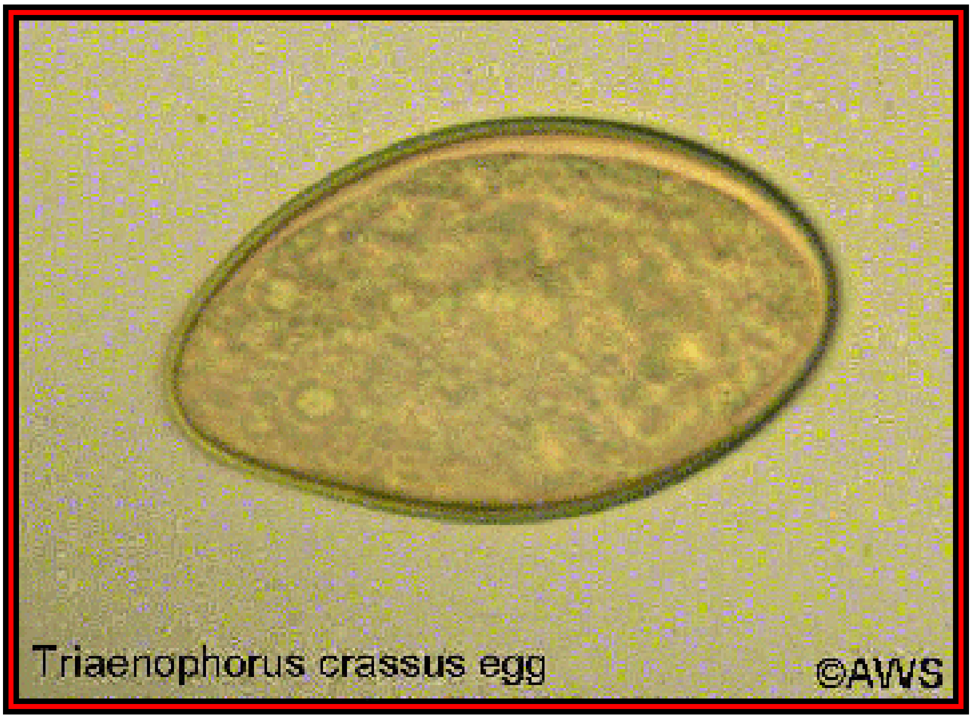
This is a rather unusual genus of psuedophyllidean cestode in that the scoleces of some species are armed with hooks.

The following three images are of different plerocercoids of this genus showing the characteristics hooks.



Triaenophorus sp. plerocercoid scolex





An egg of *Triaenophorus crassus*. Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

Triatoma infestans

Triatoma infestans and related species and genera (e.g., *Rhodnius* and *Panstrongylus*) are commonly called assassin bugs. They serve as vectors for American trypanosomiasis or Chagas' disease.

Triatoma infestans.

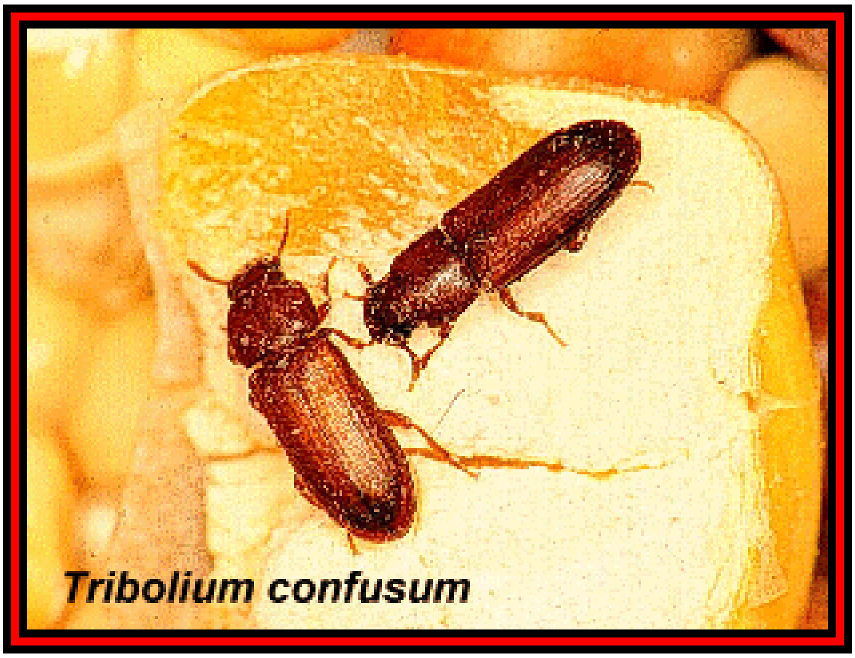
Triatoma infestans. (Original image from The Veterinary Parasitology Images Gallery, University of São Paulo, and used with permission.)

Graphic Images of Parasites

Tribolium confusum

(confused flour beetle)

Tribolium confusum is a common "pest" found in stored grain products, including grain products stored in your kitchen. The adult beeltes (see below) are about 4 mm in length, and they can serve as the intermediate host for several species of parasites, including *Hymenolepis* spp.



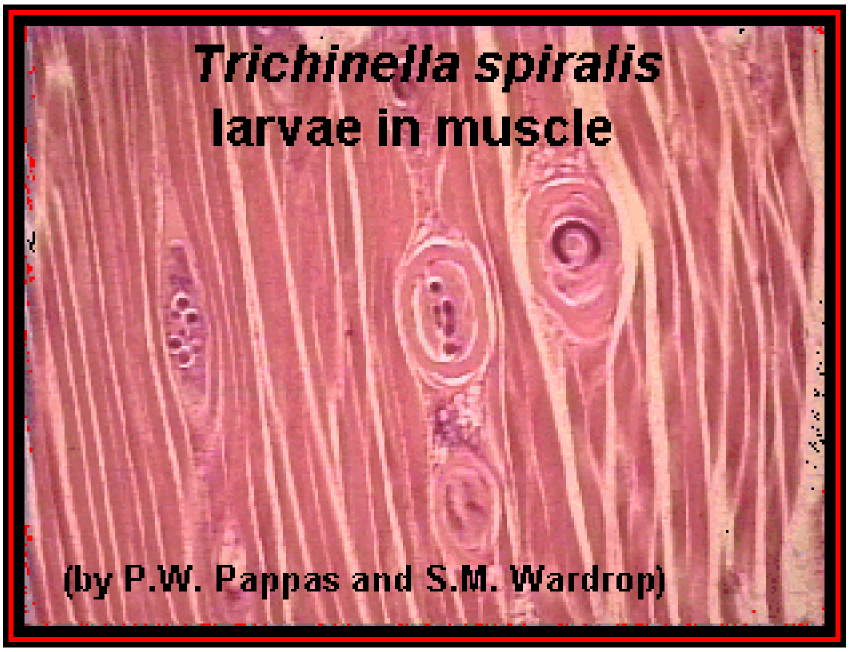
Graphic Images of Parasites

Trichinella spiralis

(Trichinellosis or trichinosis)

Unlike many parasites that demonstrate a high degree of host specificity, *Trichinella spiralis*, the trichina worm, can be found in many species of carnivores and omnivores. Animals are infected with *T. spiralis* when they ingest infective larvae (juveniles) in raw or undercooked meat. The larvae mature into adults in the host's small intestine in a few weeks, and the female worms give birth to larvae. (The males die after fertilizing the females, and the females die after producing larvae.) The larvae enter the blood stream of the host and, eventually, end up in the host's muscles. Here the larvae mature into infective larvae, and the next host is infected when it eats these larvae. In the muscles the larvae cause a severe host reaction that results in soreness and tenderness of the muscles (view diagram of the life cycle). Although this parasite probably only rarely causes fatalities in humans, it can cause extreme discomfort.

Trichinosis is probably best known as a parasite that humans contract from eating raw or undercooked pork. Through an aggressive program of meat inspection, the incidence of trichinosis in pigs in the United States has been lowered to less than 1%, so it is unlikely (but not impossible) that pork products purchased in your local supermarket will contain *Trichinella* larvae. Most recent outbreaks of trichinosis in the United States have been traced to pork products from pigs that have not been inspected and that have been slaughtered privately. Because of its low host-specificity, almost any "wild" meat should be considered suspect, and hunters should be careful when preparing meat from their kills. In particular, a number of infections have been traced to contaminated bear meat.



Trichinella spiralis larvae in muscle section.

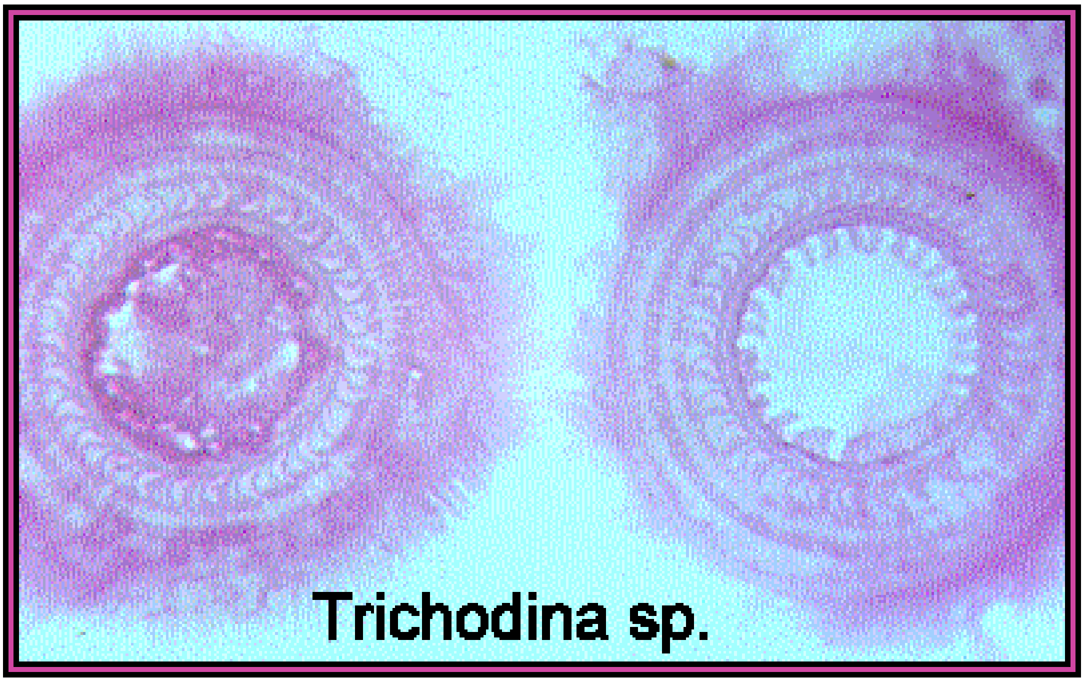
A higher power magnification of the above image.

A larva in a "teased muscle" preparation.

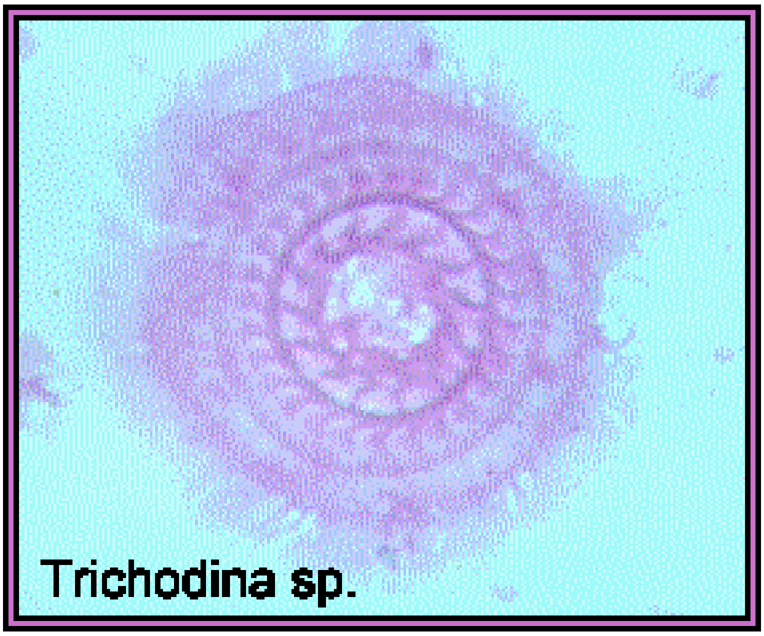
Graphic Images of Parasites

Trichodina sp.

This genus contains many species, perhaps as many as 200, most of which are found as commensals or facultative or obligate parasites on aquatic invertebrates, fish, and amphibians. All members of this genus are characterized by the presence of sclerotized "teeth" that are used to attach the organism to its "host." The presence of the "teeth" and rings of cilia give the members of this genus a characteristic (and quite beautiful) appearance.



Two examples of *Trichodina* sp. The sclerotized "teeth" are evident in the specimen on the right.



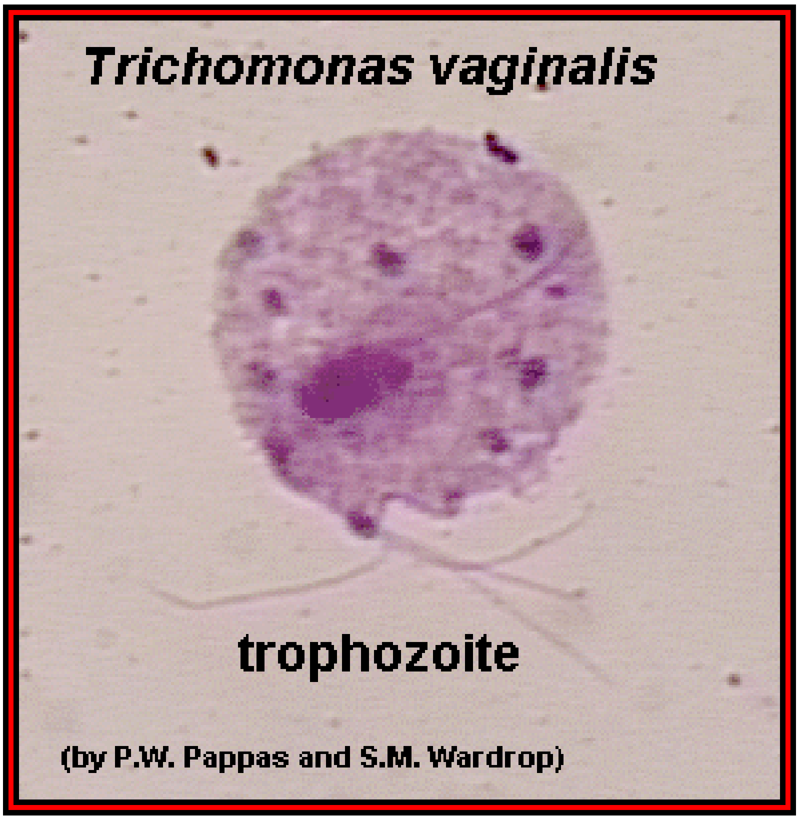
Another specimen of *Trichodina* sp. The characteristic "whorls" of cilia are apparent.

Trichodina can cause pathology is some instances. This is a rock bass infected with *Trichodina* and *Epistylis* (another ciliate).

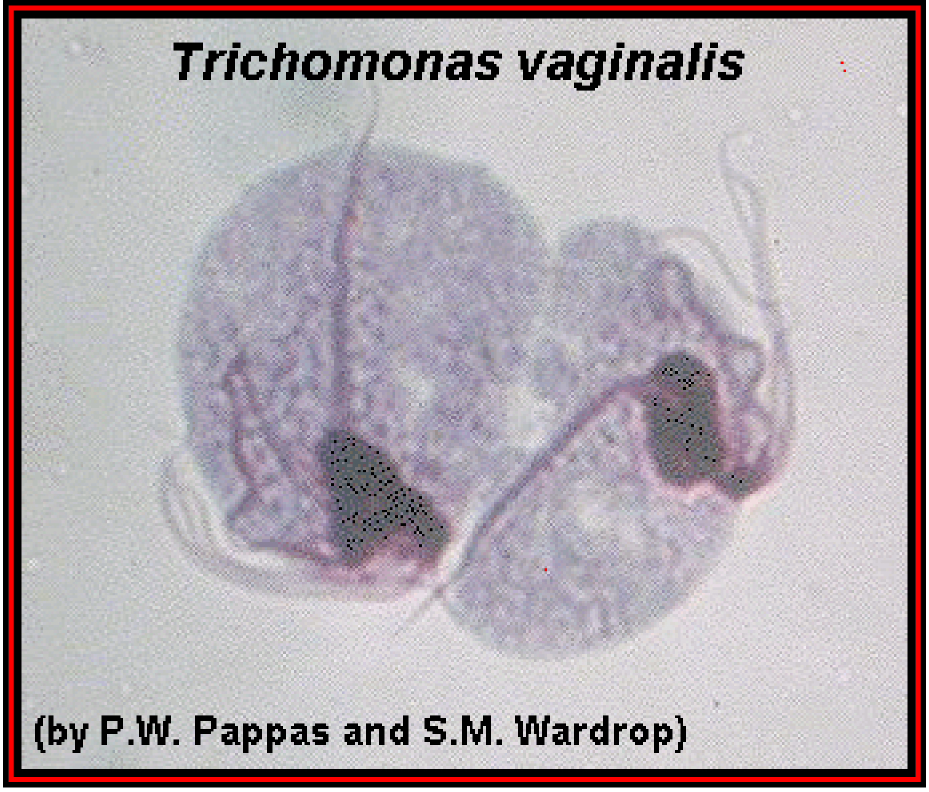
Graphic Images of Parasites

Trichomonas vaginalis
(trichomoniasis, "trich" or "trick")

Trichomonas vaginalis is a sexually transmitted disease (STD), although transmission by other routes (such as soiled towels) has been documented. There is no cyst in the life cycle, so transmission is via the trophozoite stage. Most people infected with trichomoniasis are asymptomatic. Symptomatic infections are characterized by a white discharge from the genital tract and itching. Diagnosis depends on finding trophozoites in secretions of the genital tract from men or women. In cases where the numbers of organisms are very low, the trophozoites can be cultured to increase their numbers (see below).



A trophozoite of *Trichomonas vaginalis* from culture. The four flagella and single nucleus are visible. The dark median rod is the axostyle which is characteristic of the trichomonads; approximate size = 26 µm.



Two trophozoites of *Trichomonas vaginalis*.

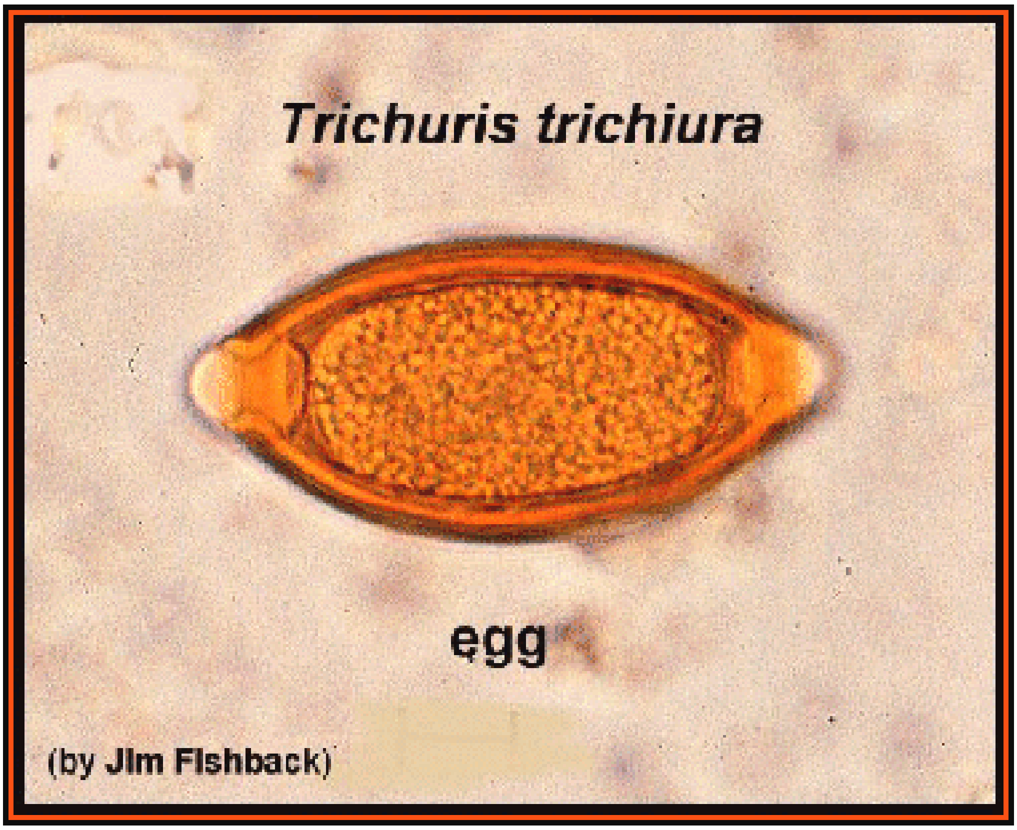
Trichuris spp.
(whipworms)

There are approximately 60 species of whipworms that infect mammals. Only two are considered here, the human whipworm, *Trichuris trichiura*, and the canine whipworm, *T. vulpis*. These two species have a high degree of host specificity, but canine whipworms have been recovered from humans on rare occasions.

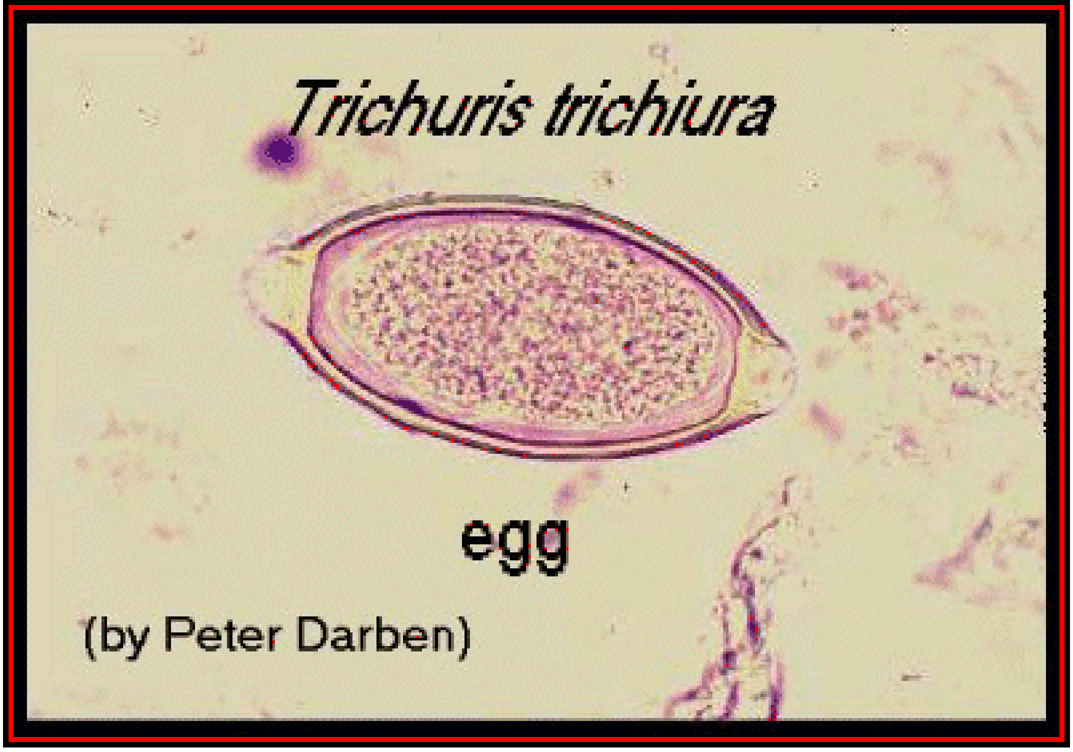
Whipworms get their name from the characteristic shape of the adults (see below). The adults live in the host's large intestine with their anterior ends embedded in the cells that line the intestine; each female can produce in excess of 10,000 eggs each day, and the worms can live several years. The eggs are passed in the host's feces, and they become infective in about three weeks. When an infective egg is eaten by the appropriate host it hatches in the small intestine, and the juvenile worm migrates to the large intestine where it reaches sexual maturity (view diagram of the life cycle).

Most infections of whipworms are probably asymptomatic. However, because the worms live a long time and a person can be reinfected constantly, heavy worm burdens can develop. Symptoms of whipworm infection can include diarrhea, dysentery, and anemia. Heavy infections in children can cause mental and physical retardation. Diagnosis depends on the demonstration of eggs, which have a characteristic appearance, in the feces.

The biology of *T. vulpis* is similar to that of *T. trichiura*, and the eggs of the two species are virtually identical.

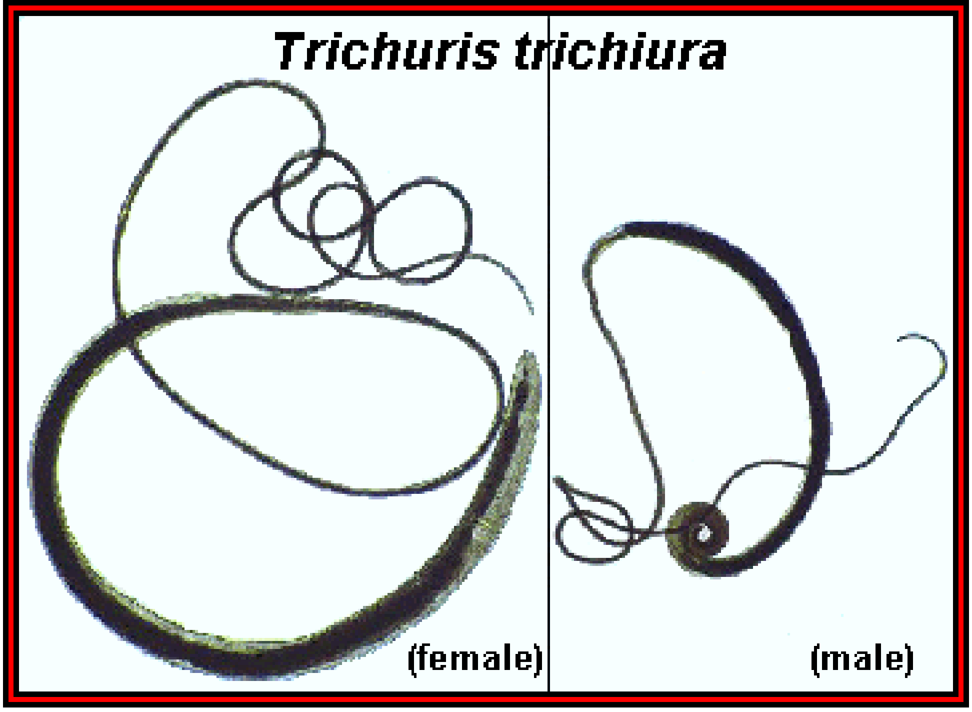


Trichuris trichiura egg. Note the characteristic "bipolar plugs;" approximate length = 50 µm



Trichuris trichiura egg.

Trichuris vulpis egg. (Original image from Michigan State University, College of Veterinary Medicine, OnLine Instructional Tutorial.)



Trichuris trichiura adults. (Original by P. Darben)

Trichuris trichiura in the large intestine. Many worms are present, each with its anterior end embedded in the intestinal mucosa, resulting in the erythema. (Original image from The Internet Pathology Laboratory for Medical Education

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The posterior end of a male *Trichuris* sp., with an everted spicule, recovered from a naturally infected *Peromyscus*.

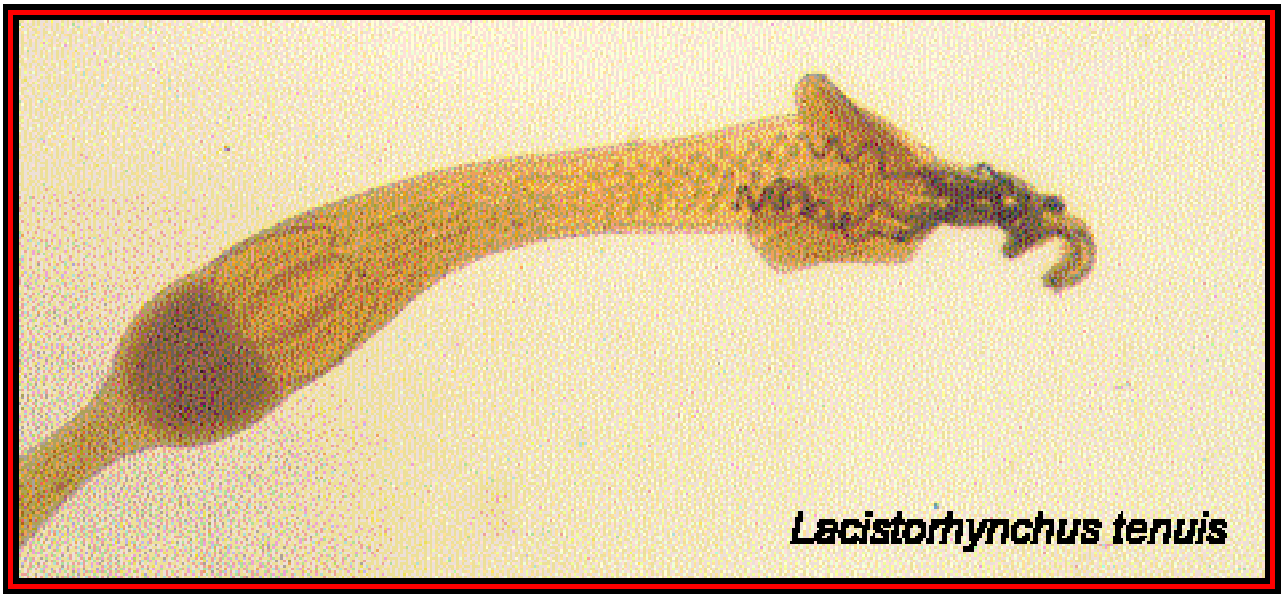
Triganodistomum sp.

A stained whole mount of an adult of *Triganodistomum* sp. recovered from a fresh water fish.

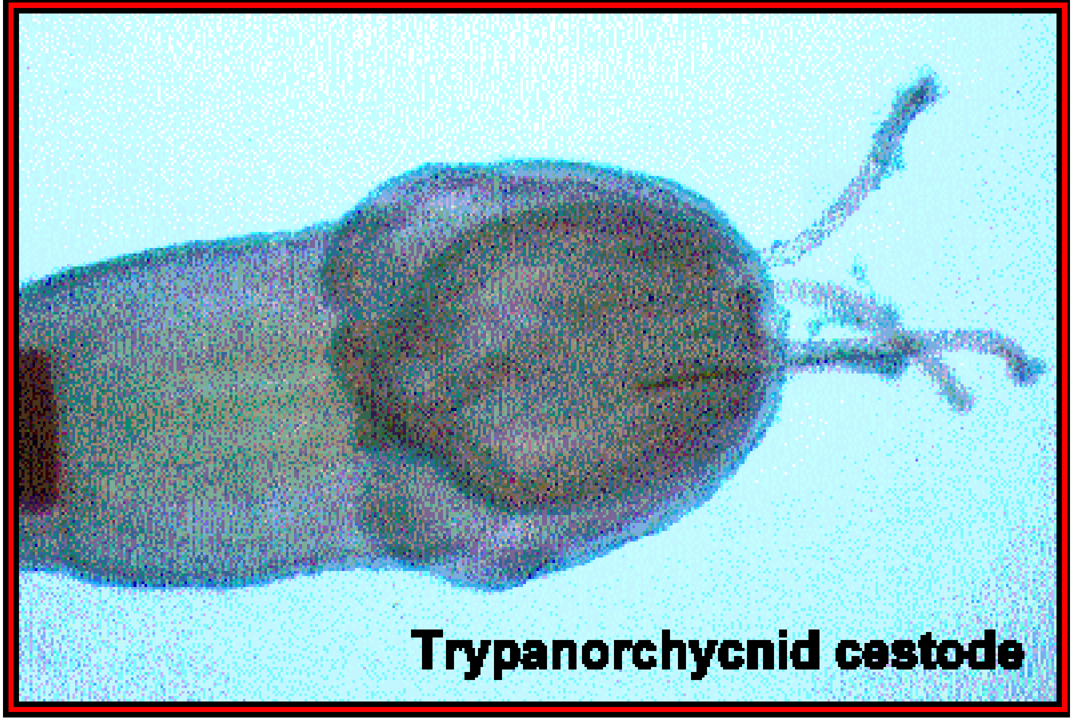
Order Trypanorhyncha

(the trypanorhynchid tapeworms)

The trypanorhynchid cestodes are parasites of the spiral valves (intestines) of elasmobranchs (sharks and rays). Only a few life cycles are known, and these involve mollusks, crustaceans, or fish as intermediate hosts. The feature that sets the trypanorhyncid cestodes apart is the morphology of the scolex. The scolex of almost all species contains two or four suckers (bothridia) and a set of tentacles. In virtually all species, the tentacles are well armed with ornate hooks, and the appearance and distribution of these hooks is important in the taxonomy of this group. The tentacles are eversible, and they appear to operate via a complex system of "bulbs" and associated plumbing in the posterior section of the scolex.



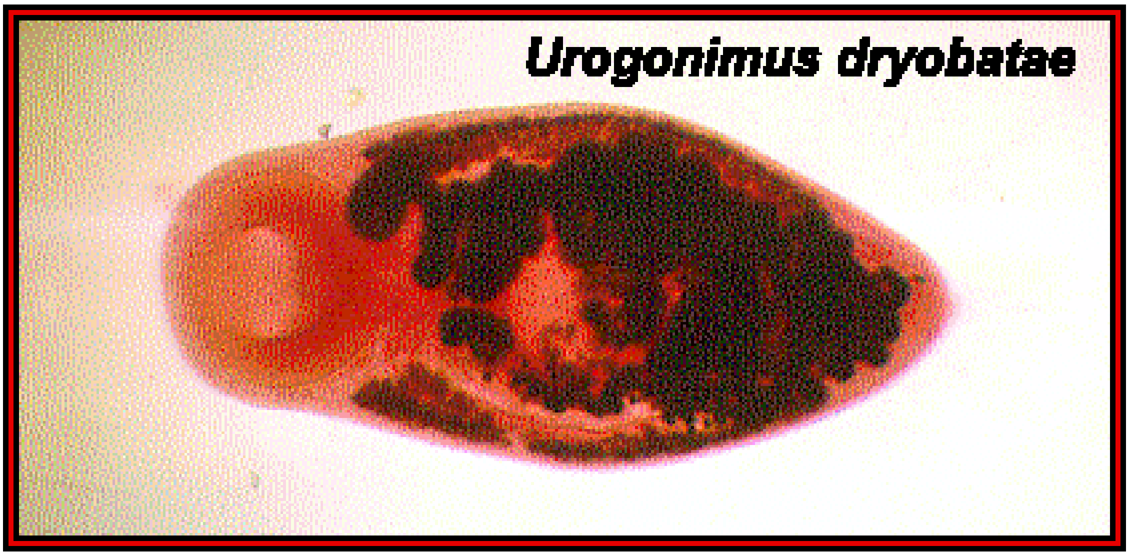
The scolex of *Lacistorhynchus tenuis*, a common parasite of many species of sharks. The morphology of the scolex is clearly visible in this preparation. The eversible tentacles and bothridia can be seen, as well as the "bulbs" in the posterior part of the scolex.



Another example of the scolex of a trypanorhyncid tapeworm. Note the eversible tentacles and bothridia.

Urogonimus dryobatae

The following two images are of adult specimens of *Urogonimus* sp. This genus is now considered to be a synonym for *Leucochloridium*.



Visceral larval migrans (VLM)

There are several examples of parasites that are normally found in pets and that can be transmitted to humans. For example, a common tapeworm of dogs, *Dipylidium caninum*, can be transmitted to humans (although only rarely). Immature forms of dog and cat hookworms can also be found in humans, causing a disease known as cutaneous larval migrans. The larvae of intestinal roundworms found in some animals can also infect humans, and this results in a disease called visceral larval migrans (VLM). The parasite implicated most often as a cause of VLM is *Toxocara canis*, the common roundworm of dogs, but nematodes of other animals can also cause VLM in humans.

If a human ingests infective eggs of a parasite such as *T. canis*, the eggs hatch in the human's small intestine, and the larvae burrow into the small intestine and enter the blood stream. From here the larvae can be distributed to almost any tissue in the body. Once the larvae are in the tissues they migrate through and damage (or kill) the host's tissue. The pathology associated with VLM depends on the tissues in which the larvae are found and the number of larvae. A few larvae migrating through a human's liver would probably result in few if any overt symptoms. However, a few larvae in the eye might cause blindness, or a few larvae in the brain might result in severe neurological disorders.

It is estimated that approximately 20% of all dogs and 95% of puppies in the United States are infected with *T. canis*, so the risk of infection with VLM is high. However, most cases probably go undiagnosed because there are few if any symptoms. If VLM is suspected a tissue biopsy can be taken and examined for migrating larvae, but finding the larvae is like "hunting for a needle in a haystack." Immunological tests are available that will detect VLM. Unfortunately, there are no drugs available that are absolutely effective against migrating larvae.

Control of VLM depends on eliminating the source of infective eggs. Thus, keeping dogs free of *Toxocara* and disposal of dog's feces are essential. Unfortunately, it is virtually impossible to eliminate all possible sources of infection, particularly in those cases where dogs are allowed to defecate indiscriminately in public areas such a parks and playgrounds (and your yard). Moreover, the eggs of *Toxocara* will survive for extended periods of time (many months under appropriate conditions) so it is possible for an area to be contaminated with eggs even though there is no obvious sign of fecal contamination.

Several other species of intestinal roundworms will cause VLM. *Toxocara cati* is a common parasite of domestic cats, and ingestion of infective eggs by humans can result in VLM. *T. cati* in humans is probably much less common than *T. canis*. *Baylisascaris procyonis* is found commonly in raccoons, and cases of VLM caused by this parasite (several of which have been fatal) have been documented. Raccoons are found commonly in rural areas, and even in many suburbs, and people encourage them to come into their yards by feeding them. Obviously, this should not be done as it just increases the chances of getting VLM.

Watsonius sp.

Two living specimens of *Watsonius* sp. recovered from a baboon. (The diameter of the coin is 20 mm.) The large, posterior ventral sucker is clearly visible in the specimen on the right.

Zonorchis sp.

A stained whole mount of *Zonorchis alveyi*.

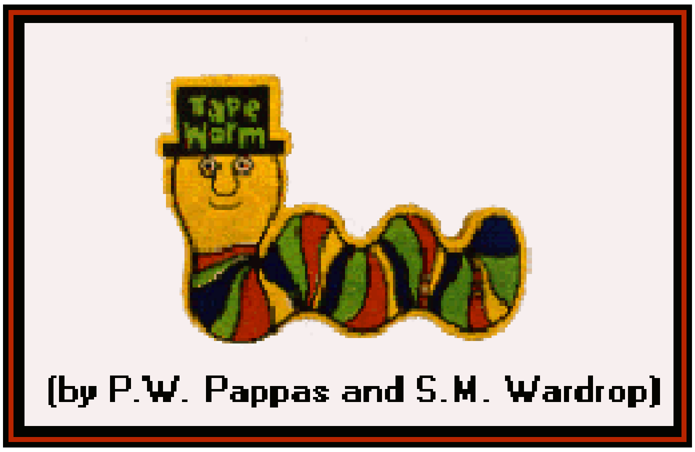
Zygocotyle lunata

This is a common parasite of ducks and other water fowl. The parasite is found in the small intestine and eggs are passed in the feces. The first intermediate host is a snail, and the cercariae that are liberated from the snail encyst on the surfaces of various objects in the water (e.g., plants, branches, etc.). The definitive host is infected when it ingests the metacercariae.

A whole mount of an adult *Zygocotyle lunata*. Adults of this species can measure up to 9 mm in length. Note that the acetabulum is at the posterior end (right side of image). Original image copyrighted and provided by Dr. A.W. Shostak, and used with permission.

A Most Unusual Specimen

Parasites "exploit" their hosts, but humans also exploit parasites. This is but one example of how parasites are exploited for commercial purposes. This "tapeworm" is actually a dispenser for cellophane ("Scotch") tape. The roll of tape fits behind the tapeworm's "head," and the cutter for the tape is located at the tapeworm's "tail." This was actually puchased at a stationary store, but it was so long ago that I forgot when.



The "tapeworm" that dispenses cellophane tape; approximate size = 5 inches.